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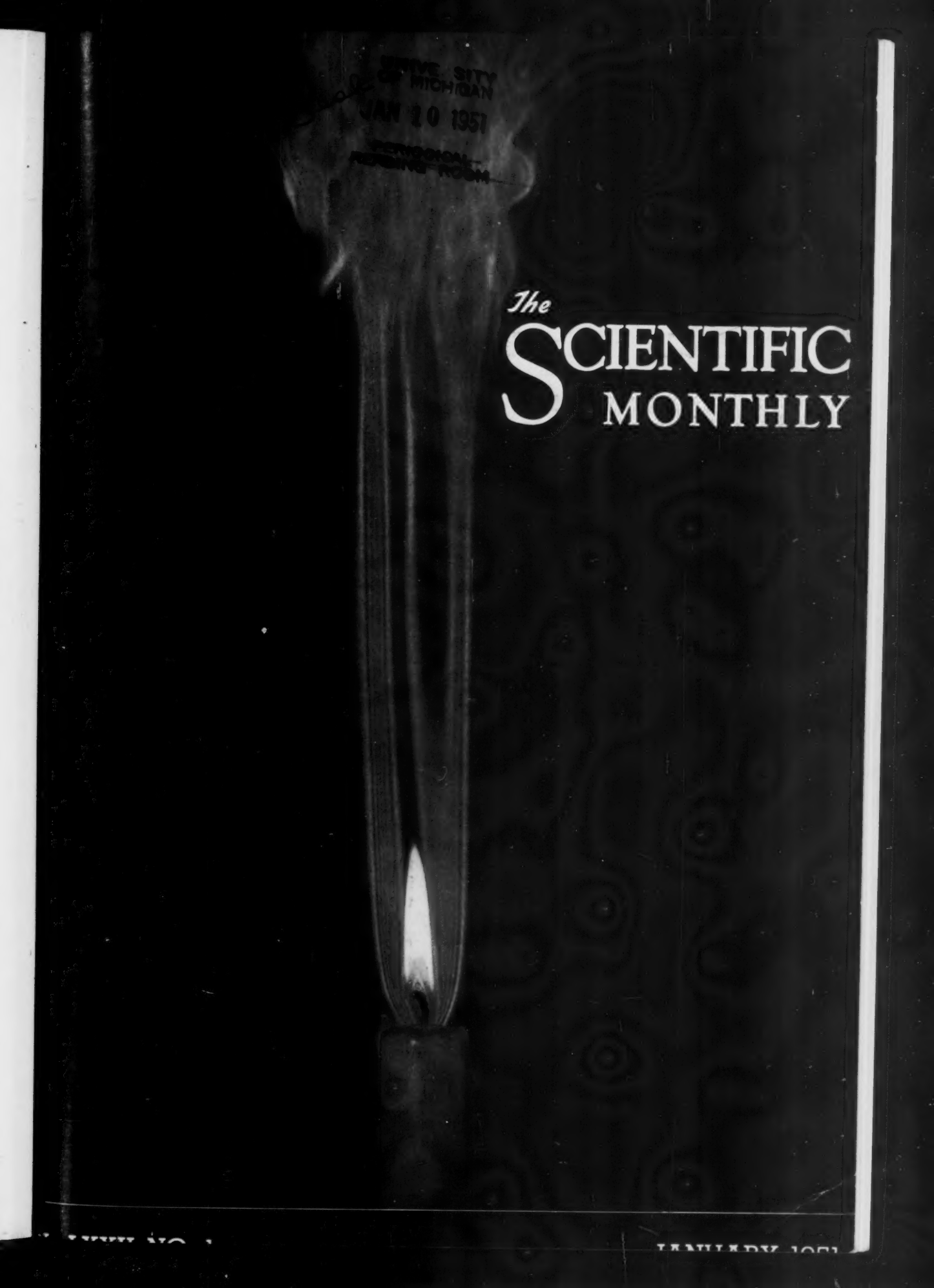
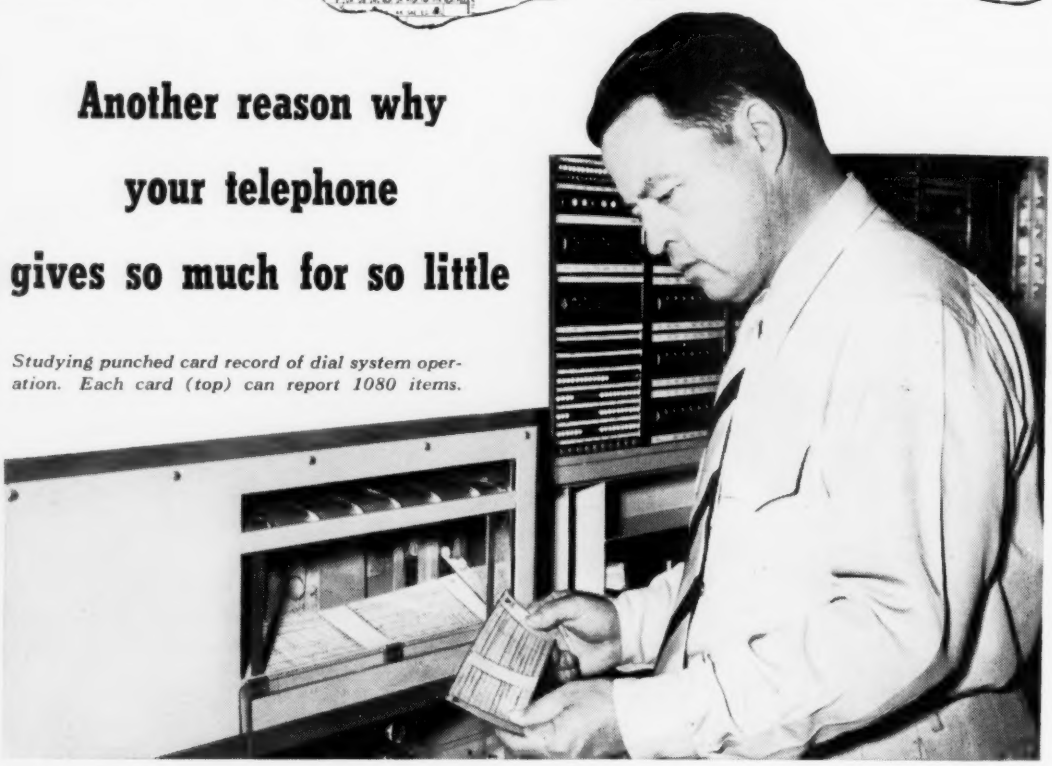


The SCIENTIFIC MONTHLY

JANUARY 1951

Another reason why your telephone gives so much for so little



Studying punched card record of dial system operation. Each card (top) can report 1080 items.

In a large, modern dial telephone office, 2,000,000 switch contacts await the orders of your dial—and 10,000 of them may be needed to clear a path for your voice when you make a single telephone call. Within this maze of signal paths, faults—though infrequent—must be detected and fixed before they can impair telephone service.

The latest system developed by Bell Telephone Laboratories automatically detects its own faults, detours calls around them without delay—then makes out a "written" report on what happened.

The fault may be a broken wire, or a high resistance caused by specks of dirt on switch contacts. In a second, the trouble recorder punches out a card, noting the circuits involved and the stage in the switching where the fault appeared.

Maintenance men examine the reports at intervals and learn what needs attention. Between times they go about their own duties in keeping service moving.

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THE SCIENTIFIC MONTHLY

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Science and Technology

(From the Month's News Releases)

Barometer

An aneroid barometer, accurate to 1/1,000 inch of mercury, is now on the market. Of importance for industrial and military use, it reliably indicates minute changes in air pressure instantly, without the necessity of corrections for temperature and altitude. It is furnished with either wall mounting flange or leather carrying case.

Safe Water

Wherever drinking water must be obtained from a well, spring, or other unprotected source, contamination may be neutralized by the use of an ultraviolet water sterilizer, according to its manufacturer, the Sepco Corporation. The device requires no attention, uses no chemicals, and adds no taste or odor to the water. In addition, installation is quick and inexpensive.

Publications Noted

Research Is Learning, by the Engineering College Research Council, representing the research activities of 82 institutional members of the American Society for Engineering Education.

Heart Disease—A Story of Progress. Federal Security Agency, National Heart Institute, Bethesda 14, Md.

Nature Writings. Cornell Rural School leaflet, published by The New York State College of Agriculture at Cornell University. Prepared and supervised by E. Laurence Palmer and Eva L. Gordon.

Nutrition for Everyday Use, a handbook of teaching aids, and *Safe Milk*, a résumé of present information, are new publications of the National Dairy Council.

Outline of the History of Chemistry, prepared by Herbert S. Klickstein for Mallinckrodt Chemical Works is being distributed nationally to chemists, schools, and libraries. In the form of a flow sheet, it consists of two charts printed side by side on a sheet of paper measuring $35'' \times 35\frac{1}{2}''$.

Tobacco and Sugar, by Francis Joseph Weiss, special research consultant, is available from the Sugar Research Foundation, 52 Wall St., New York City.

Better Health through Better Rice is a publication of the Williams-Waterman Fund, which is administered by Research Corporation. Robert R. Williams, of Vitamin B_1 fame, is now on a world tour seeking to better the nutritional status of rice-eating peoples. He is chairman and co-founder of the Fund.

Genetics—The Science of Heredity, by science writer John Pfeiffer, is a new Public Affairs pamphlet. It may be obtained from the Public Affairs Committee, 22 E. 38th St., New York City, for 20 cents.

The New York State Joint Legislative Committee on Problems of the Aging has just published *Young at Any Age*, a comprehensive, illustrated report in 192 pages on the work of the Committee. Free on request.

Agricultural Climatology of Siberia, Natural Belts, and Agro-Climatic Analogues in North America is Study No. 13 of the American Institute of Crop Ecology, Washington, D. C.

Properties of Flammable Liquids, Gases and Solids, first printed fifteen years ago, has appeared in a 1950 edition. Key feature is a table of more than 650 flammable materials found in industrial plants, giving for each the chemical formula, flash point, explosive limits, auto-ignition temperature, specific gravity, and other data.

Labels

A heavy cellulose tape, printed in vivid colors with the words "Poison," "Corrosive," and "Flammable," is available in a heavy dispenser containing three ½-inch rolls of about 200 printed portions each. Another variety, in 500-inch rolls, in widths up to 1 inch, adheres firmly to metal, paper, glass, or plastic, and is oil-, tamper-, water- and smudgeproof. This one is of the make-your-own-label type.

New Publications

The new official journal of the American Academy of Neurology is making its debut this month. Called *Neurology*, it will be published bimonthly under the editorship of Russell N. De Jong (84 S. 10th St., Minneapolis, Minn.).

Mental Health in Virginia is the name of a new quarterly being published by the State of Virginia and the Virginia Mental Hygiene Society.

The Sarawak Museum, Kuching, Sarawak, has recently revived its publication *Sarawak Museum Journal*. A large proportion of space will be devoted to anthropology, ethnology, and archaeology, but zoological, botanical, meteorological, and geological contributions will be published. The subscription price is approximately $2.50.

Focus, a four-page information journal to be issued monthly except July and August, has just been started by the American Geographic Society. World problems and events from the viewpoint of scientific geography will be considered. The first issue deals with Korea, and forthcoming issues will discuss Russia's petroleum resources, the water problem of the United States, and strategic Iran.

The American Society of Naturalists has assumed editorial control of *The American Naturalist*. A subscription to that journal is now included in the dues at a special reduced rate.

CARE for Children

A Children's Book Fund Program, to promote better understanding between the young people of the world, has been launched by CARE and UNESCO. The new service supplements the regular book fund, which sends new scientific and technical works overseas, and will operate similarly. Two types of "Book Shelf" have been compiled for sending abroad: A series of 33 picture books for young children, and a collection of 32 books for older boys and girls who are learning English as a second language. Ranging from Mother Goose rhymes to simply written histories and geographies of the United States, selections from either Book Shelf may be ordered in any of five package units of $10 each, or $50 for a complete shelf.

For Scientists and Travelers

A map scaled at 1:125,000, with contour intervals of 100 feet, of the Great Smoky Mountains National Park and surrounding areas on the Tennessee-North Carolina border is now available from the Geological Survey.

shaded relief edition of the map brings out the hills and valleys of the area in striking fashion, to appeal to travelers and park visitors; the contours without the shading will appeal to engineers, geologists, and others accustomed to reading precise maps. The reverse side contains information, diagrams, sketches, and botanical drawings, based on the article by Philip B. King and Arthur Stupka in THE SCIENTIFIC MONTHLY (**71**, 31 [1950]).

Removable Markings

Marking crayons whose patented soap base allows markings to be wiped off with a damp cloth without marring the appearance or surface of metal, crockery, glass, wood, or lumber, were originally designed for furniture factories and lumber mills, but would be useful in a home workshop. They come in eight sharp, distinct colors.

Put Down that Hammer!

Plastic hooks that require no screws, nails, or tools and guaranteed by the manufacturer to hold fifteen pounds, will permanently adhere to tile, plaster, glass, wood, or metal. Available in seven colors, they are priced at two for 25¢.

Is Your Room Tired?

Decor-Mould, for closet shelving, bookcase edging, door trims, etc., is now available in packages containing two four-foot lengths for $1.98. It is deeply scored at intervals of 3½ inches, making it possible to break the moulding by simple hand pressure to make it fit any shelf. It is predrilled and comes in six colors and unpainted.

Smooth Stops

When you ride in the new Westinghouse elevator you save not only time but wear and tear on your nerves as well. Most passengers won't know the exact moment when the elevator stops. The newly developed Synchro-Glide Landing system is almost infallibly accurate. Gliding to a stop saves 1½ seconds on each floor-to-floor trip, thus increasing the passenger-handling capacity of a car up to 10 per cent.

What Could Do More?

The Fresh'nd-Aire Wall-aire, a new electric appliance, combines, among other features, a bathroom heater, cooling fan, hair dryer, and a rapid clothes dryer in one compact unit that can be hung anywhere without the use of holes, screws, hooks, or nails . . . once up, it looks like a built-in wall panel unit. It sells for $39.95.

Distilled Water from Any Faucet

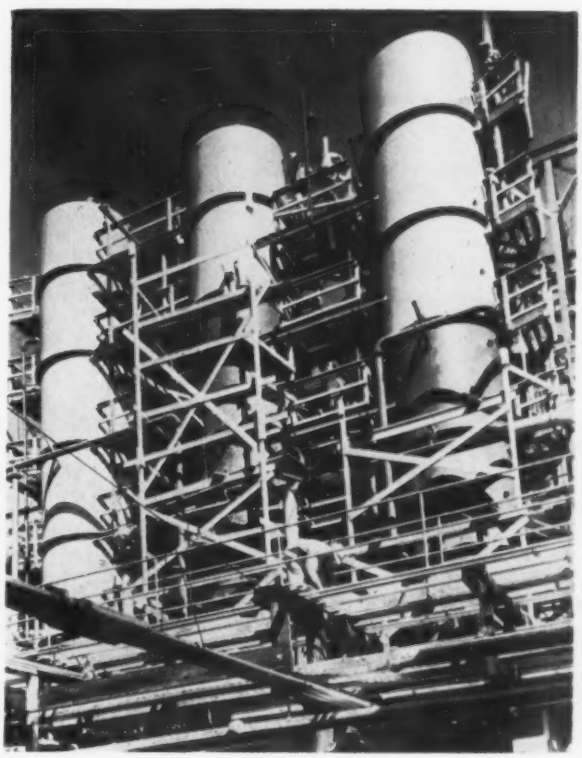
Designed for small-quantity uses where elaborate equipment would be impractical (such as soil analysis, photography, and general laboratory work) a refillable ion exchange unit now delivers, from an ordinary faucet, water equal in chemical quality to triple-distilled. Filtr-Ion is a small, low-cost application of the Monobed ion exchange principle. It is a transparent plastic tube, filled with Amberlite ion exchange resins, which is slipped over the end of a cold water faucet; small holes in the top cap prevent excessive flow through the bed of resins. As water passes through the apparatus, metallic and other ionic solids are taken out of solution by the mixture of anion and cation exchangers. Fiberglas filters tap physical impurities. Normally, up to 10 gallons of laboratory quality water may be expected from each unit.

For a Quick Look

A new method of projecting and storing slides, the Automatic Slide Changer for $2'' \times 2''$ slide projectors, has just been introduced. The device automatically selects and centers the slide in the correct focal plane, regardless of the thickness of the mount, then returns it, after projection, to its original place in the magazine. The changer fits over twenty-four popular projector models, and costs $14.95.

Tailored to Your Car

Elastic upholstery material, with a high slip finish, has been developed by U. S. Rubber Company for use in automobiles, buses, trucks, and furniture. The material is made of Naugahyde, a new type of vinyl plastic, which will stretch in every direction. It combines a special elastic supporting fabric and an elastic plastic coating, developed after five years of experimentation. Sold in rolls 30–40 yards long and 47 inches wide, in five stock colors, it is easy to handle, needs no wetting, special tools, tape, or cement for application, and does not bag or wrinkle. Highly resistant to scuffing and tearing, it can be washed with soap and water, will not crack or flake, and is not harmed by oils, greases, gasolines, or alkalis.



First of the nation's stand-by GR-S synthetic rubber plants to be ordered back into production under the government's expanded program has already been reactivated by Naugatuck Chemical Division, U. S. Rubber Company. Above, workmen check the huge stripping columns where synthetic rubber latex is purified.

New Books Received

Chemistry Visualized and Applied. Armand Joseph Courchaine. M. Cordelia Cowan, Ed. viii + 387 pp. Illus. $5.50. Putnam's. New York. 1950.

The Care and Breeding of Laboratory Animals. Edmond J. Farris, Ed. xvi + 515 pp. Illus. $8.00. Wiley. New York. 1950.

Forest Management. Herman H. Chapman. xix + 582 pp. (No price given.) Hildreth Press. Bristol, Conn. 1950.

An Autobiography. Sir Arthur Keith. vi + 721 pp. Illus. $4.75. Philosophical Library. New York. 1950.

The Smithsonian. Webster Prentiss True. ii + 306 pp. Illus. $3.50. Sheridan House. New York. 1950.

The Art of Scientific Investigation. W. I. B. Beveridge. viii + 171 pp. Illus. $3.00. Norton. New York. 1950.

Security, Loyalty and Science. Walter Gellhorn. viii + 300 pp. $3.00. Cornell University Press. Ithaca, N. Y. 1950.

Life and Work of Sir S. S. Bhatnagar. Norah Richards. vi + 239 pp. Illus. $1.50. New Book Society of India. New Delhi. 1948.

Marine Geology. Ph. H. Kuenen. x + 568 pp. Illus. $7.50. Wiley. New York. 1950.

Bibliography and Index of Geology Exclusive of North America. (Vol. 14–1949). Marie Siegrist. xii + 375 pp. (No price given.) Geological Society of America. 1950.

Principals of General Psychopathology. Siegfried Fischer. xviii + 327 pp. $4.75. Philosophical Library. New York. 1950.

Theory of Mental Tests. Harold Gulliksen. xix + 386 pp. Illus. $6.00. Wiley. New York. 1950.

The Nininger Collection of Meteorites. H. H. and Addie Nininger. viii + 144 pp. Plates. (No price given.) American Meteorite Museum. Winslow, Ariz. 1950.

Dementia Praecox, or the Group of Schizophrenias. Eugen Bleuler. Trans. by Joseph Zinkin. 547 pp. $7.50. International Universities Press. New York. 1950.

Principles of Psychology. Fred S. Keller and William N. Schoenfeld. xv + 431 pp. Illus. $4.00. Appleton-Century-Crofts. New York. 1950.

Quakers in Science and Industry. Arthur Raistrick. vii + 361 pp. Illus. $6.00. Philosophical Library. New York. 1950.

Colloidal Dispersions. Earl K. Fischer. vii + 387 pp. Illus. $7.50. Wiley. New York. 1950.

Water, Land, and People. Bernard Frank and Anthony Netboy. xviii + 331 pp. Illus. $4.00. Knopf. New York. 1950.

Introductory Nuclear Physics. David Halliday. ix + 558 pp. Illus. $6.50. Wiley. New York. 1950.

Deciduous Forests of Eastern North America. E. Lucy Braun. xiv + 496 pp. Illus. $10.00. Blakiston. Philadelphia. 1950.

Personality and Psychotherapy. John Dollard and Neal E. Miller. xiii + 488 pp. Illus. $6.50. Textbook ed., $5.00. McGraw-Hill. New York. 1950.

Current Trends in the Relation of Psychology to Medicine. Wayne Dennis, Robert H. Felix, Carlyle Jacobsen, Robert Patton, Yale D. Koskoff, Paul E. Huston, Nathan W. Shock, and Hans J. Eysenck. 189 pp. $3.75. University of Pittsburgh Press. 1950.

Genes, Plants and People. C. D. Darlington and K. Mather. ix + 187 pp. $4.00. Blakiston. Philadelphia. 1950.

Industrial and Safety Problems of Nuclear Technology. Morris H. Shamos and Sidney G. Roth, Eds. vi + 368 pp. $4.00. Harper. New York. 1950.

Annual Review of Physical Chemistry. (Vol. I). G. K. Rollefson, Ed. vii + 382 pp. Illus. $6.00. Annual Reviews, Inc. Stanford, Calif. 1950.

Die Welt der chemischen Körper bei hohen und tiefen Temperaturen und Drucken. Ernst Janecke. viii + 122 pp. Illus. (No price given.) Verlag Chemie, GMBH. Weinheim, Germany. 1950.

Pelagic Tunicates of Australia. Harold Thompson. iv + 196 pp. Plates. (No price given.) Commonwealth Scientific and Industrial Research Organization. East Melbourne, Australia. 1948.

A Handbook of Private Schools. (32nd ed.). Porter Sargent. x + 1004 pp. Illus. (No price given.) Porter Sargent. Boston. 1950.

New Ways to Better Sight. (2nd ed.). Harris Gruman. viii + 207 pp. Illus. $3.50. Shayne-Dell Press. Lebanon, Pa. 1950.

Man the Tool-Maker. (2nd ed.). Kenneth P. Oakley. v + 98 pp. Illus. (No price given.) British Museum (Natural History). London. 1950.

Twilight in South Africa. Henry Gibbs. viii + 288 pp. Illus. $4.50. Philosophical Library. New York. 1950.

Mycotrophy in Plants. Arthur P. Kelley. xv + 223 pp. Illus. (No price given.) Chronica Botanica. Waltham, Mass. 1950.

Bird's-Eye View of the Pueblos. Stanley A. Stubbs. x + 122 pp. Illus. $3.00. University of Oklahoma Press. Norman. 1950.

Health Instruction Yearbook 1950. Oliver E. Byrd. ix + 270 pp. $3.50. Stanford University Press. 1950.

Masks as Agents of Social Control in Northeast Liberia. George W. Harley. xiv + 45 pp. Illus. (No price given. Peabody Museum of American Archaeology and Ethnology, Harvard University. Cambridge. 1950.

Contributions to the Biology of the Philippine Archipelago and Adjacent Regions. Charles Branch Wilson. iii + 441 pp. Illus. (No price given.) Smithsonian Institution. 1950.

Maya Hieroglyphic Writing. J. Eric S. Thompson. xv + 347 pp. Illus. $7.50. Carnegie Institution. Washington, D. C. 1950.

Amphibians of Western China. (Vol. 2). Ch'eng-chao Liu. xiv + 400 pp. Illus. $7.50. Chicago Natural History Museum. 1950.

Some Applications of Statistics to Archaeology. Oliver H. Myers. 37 pp. Illus. (No price given.) Government Press. Cairo. 1950.

Maize in the Great Herbals. John J. Finan. xv + 191 pp. Illus. (No price given.) Chronica Botanica. Waltham, Mass. 1950.

Feelings and Emotions. Martin L. Reymert, Ed. xviii + 603 pp. Illus. $6.50. McGraw-Hill. New York. 1950.

Numerical Mathematical Analysis. (2nd ed.). J. B. Scarborough. xviii + 511 pp. $6.00. The John Hopkins Press. Baltimore. 1950.

Colorimetric Determination of Traces of Metals. (Vol. 3, 2nd ed.). E. B. Sandell. xix + 673 pp. $9.00. Interscience Publishers. New York. 1950.

The "Why" of Man's Experience. Hadley Cantril. xiii + 198 pp. $2.75. Macmillan. New York. 1950.

Modern Chemical Processes. Editors of *Ind. & Eng. Chem.* iii + 222 pp. Illus. $4.00. Reinhold. New York. 1950.

New Atoms. Otto Hahn. viii + 183 pp. $1.75. Elsevier. New York. 1950.

Sir Thomas Browne. Jeremiah S. Finch. ii + 319 pp. Illus. $3.50. Schuman. New York. 1950.

The Mammals of Victoria. C. W. Brazenor. iv + 125 pp. Illus. (No price given.) Brown, Prior, Anderson, and Melbourne for National Museum of Victoria. 1950.

Sourcebook on Atomic Energy. Samuel Glasstone. 548 pp. Illus. $2.90. Van Nostrand. New York. 1950.

Culture in Crisis. Laura Thompson. viii + 221 pp. Illus. $4.00. Harper. New York. 1950.

The Burden of Diseases in the United States. Alfred E. Cohn and Claire Lingg. viii + 129 pp. Illus. (additional vol. of charts). $10.00. Oxford University Press. New York. 1950.

THE
SCIENTIFIC MONTHLY

JANUARY 1951

Pygmy Elephant and Giant Tortoise

DIRK ALBERT HOOIJER

The author is a specialist on extinct and living animals of Asia and has published numerous articles on this subject. He lived for more than ten years in the Orient, and is a curator of vertebrate paleontology at the State Museum of Natural History at Leyden. At the moment he is working on collections of fossil mammals from China in the American Museum of Natural History. In his present article the emphasis is on the early fauna of Celebes, one of the largest of the East Indian Oceanic islands, a most promising new field of research opened up only a few years ago.

SOUTHEASTERN Asia has long been a most critical area with regard to research on early man. It was the discovery of the first skull cap of *Pithecanthropus* early in the nineties, in the Pleistocene strata of Java, by the Dutch army physician Eugène Dubois, that drew the world's attention to the bone-bearing beds of this island.

As a result of energetic searches made by G. H. R. von Koenigswald, one-time paleontologist to the Geological Survey of the Dutch East Indies during the 1930s, these Pleistocene strata in Java were found to contain not only more skulls and teeth of ape men of various sizes, but also what was held by this scientist to be the handiwork of these creatures, namely, Paleolithic stone flakes of a special type, the Sangiran culture.

The stone flakes, as later research by De Terra and Movius has shown, have not been found to occur in exactly the same layers as those containing the skulls and mandibles of *Pithecanthropus,* but nevertheless they can be regarded as the work of creatures with an intelligence superior to that of the apes. They are thus indicative of the presence of some sort of fossil man—in the present case most probably Solo Man, a pre-Neanderthal type of Upper Pleistocene age in Java, of which not less than eleven skulls and two leg bones have been unearthed thus far.

The searches for fossil man initiated purposeful collecting of fossil vertebrates on a large scale, and the fossil vertebrate fauna of Java is now known to comprise at least seventy-five different species of mammals belonging to various consecutive faunas, and it provides a rather good impression of the composition and evolution of the mammalian fauna of Java to which *Pithecanthropus* belongs.

It was clear from the very beginning of the search that the fossil fauna of Java was derived, at least in part, from that of the Asiatic mainland known as the Siwalik fauna, which was discovered in India south of the main Himalaya Mountain

range, as well as in Upper Burma, more than a hundred years ago. In comparison with the Indian fossil fauna, the Javan lacks the horses, camels, giraffes, and most of the antelopes, which were all animals of the open plains and deserts; but the giant tortoise, rhinoceros, hippopotamus, deer, cattle, etc., of Java and India are closely related.

In recent years von Koenigswald has found that the fossil mammalian fauna of Java is also linked with that of China. It is his opinion that Java received its gibbons, orangutan, *Pithecanthropus* (?), sun bear, hyena, tapir, etc., directly from China, via land bridges that at one time or another must have existed over Formosa, Luzon, Palawan, and Borneo. Java and Borneo belong to a continental area, the Sunda Shelf. In Pleistocene times the sea level was lowered by not less than two hundred and forty feet (forty fathoms, see Fig. 1) as a result of the freezing of large quantities of water in the arctic and antarctic regions and on high mountains. Other factors were certainly involved, too, but at any rate there was a marked recession of the sea in this area. Consequently the animals and man were able to make their way to these Greater Sunda Islands of today dry-shod from what is now the Asiatic continent (see Route 1, Fig. 1).

It is not absolutely necessary to assume that these supposedly Chinese components of the fossil fauna of Java came all the way from China across these circuitous land bridges through the Philippine Islands, and not simply over Sunda land. Moreover, the geological evidence of a Pleistocene land bridge between Luzon and Borneo past Palawan is not very conclusive, and I think we can safely dismiss this suggestion.

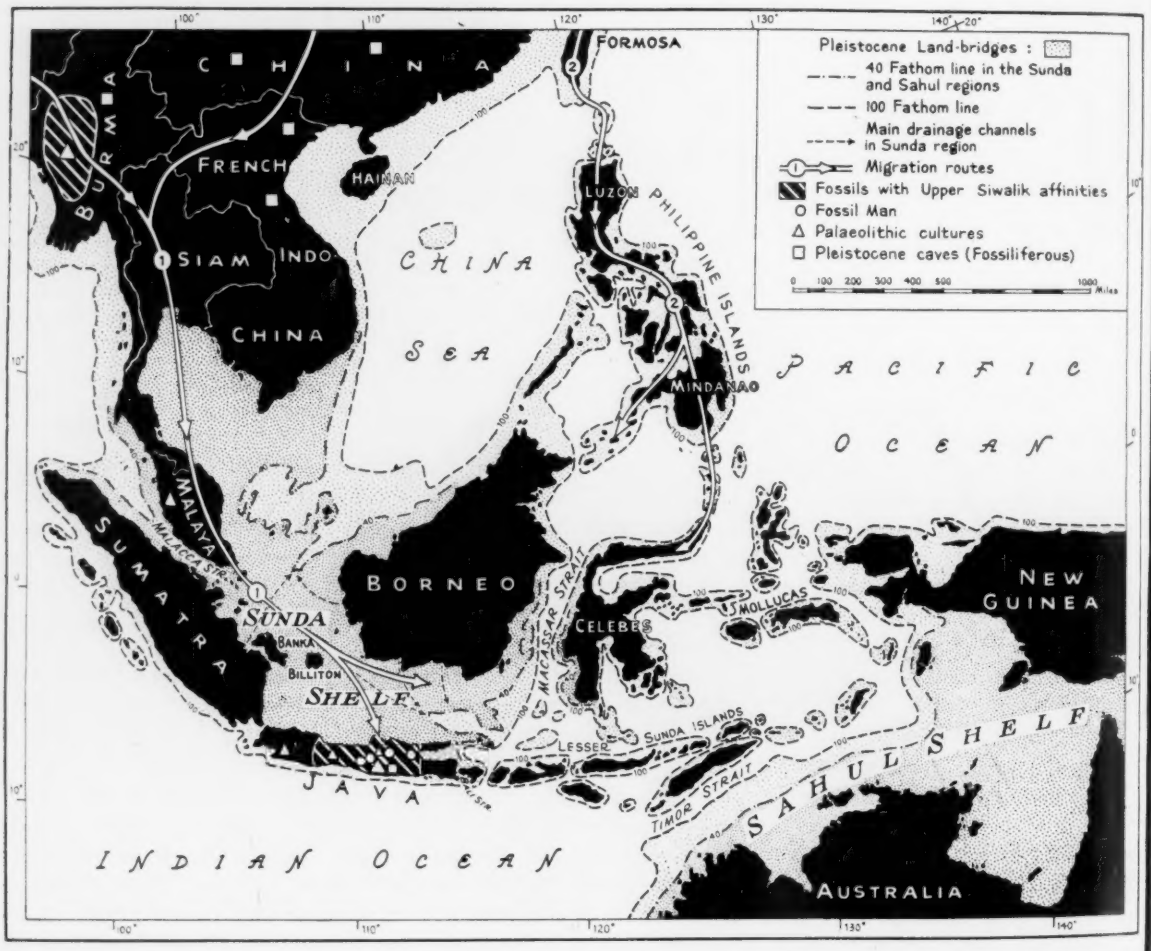


FIG. 1. Pleistocene land connections in the Malaysian area during the glacial periods of low sea level, with suggested migration routes. Route 1 is the migration route from India, Burma, and China via French Indo-China, Siam, and Malaya south to Java. Route 2 is the migration route from China via Formosa and the Philippine islands of Luzon and Mindanao, south to Celebes. In the southwestern peninsula of the island of Celebes the fossils discussed in the present paper have been found. (After De Terra, 1943.)

The island of Celebes, however, is strictly an oceanic island, and it was not likely that fossil vertebrates of Siwalik or Chinese affinities would be found there. In fact, the so-called Wallace's Line, supposed boundary between the fauna of the Malay Archipelago of Oriental origin and that which came from Australia, has always been drawn to the west of Celebes through the Strait of Macassar. This strait between Borneo and Celebes, which is now six thousand feet deep locally, has never been narrower than about twenty-five miles during the period under consideration. However, neozoologists have had to account for the presence of Asiatic land animals on the island of Celebes!

The recent fauna of Celebes, which is about one fourth Australian in origin, does contain several endemic mammalian genera of Asiatic origin. A luwak, or palm civet, with a banded tail (*Macrogalidia*), a macaque and another monkey (*Cynopithecus*) with some resemblence to the African baboons, two species of sapiutan, anoa, or pygmy buffalo (*Anoa*), a wild boar, and the babirusa, or deer hog (*Babirussa*), with peculiar, very long and slender tusks piercing the upper lip and growing upward and backward in front of the eye, are among the best-known mammals native to Celebes. There also are several genera of gigantic rats.

As to how these land animals reached the island, various theories have been advanced. Geological studies of Celebes and of the seas around it indicate that there may have been a land bridge from Mindanao over the Sangihe Islands to the northernmost tip of Celebes while sea level was lower, perhaps as much as six hundred feet (a hundred fathoms, see Fig. 1) lower than it is today. This migration route is indicated as Route 2 on Figure 1.

Recently H. R. van Heekeren, prehistorian to the Archaeological Survey at Macassar, made brilliant finds in the mountainous southern peninsula of Celebes. Guided by information from the natives, he explored an area around Tjabengè between the Walanae River and the Singkang depression, about one hundred kilometers northeast of Macassar, consisting of folded hills and strongly eroded escarpments. A number of Paleolithic stone flakes were picked up, together with some teeth and bone fragments of animals. These remains are as heavily fossilized as those of the Pleistocene of India or Java, though they proved to belong to animals quite different from those known from the ancient faunas of these parts of the world.

First of all, there was a pygmy elephant, *Archidiskodon celebensis,* standing only six feet high at the shoulder when adult, as compared with nine feet for the living Asiatic elephant. In the structure of its grinders the Celebes dwarf, however, seems to be very closely related to an early elephant that roamed southeastern Asia in the Lower Pleistocene, half a million years ago. This early elephant from India, China, and Java (*A. planifrons*) is very similar to that of Celebes but is about twice as large in linear dimensions.

Insular animals are typically smaller than their close relatives on the mainland, but this is by no means a hard-and-fast rule. Among reptiles, for instance, it is true only in 50 per cent of the number of cases known, though it is difficult to explain why this is so. As a matter of fact, large animals require more food for their sustenance than smaller ones, and a restricted habitat may provide less food than the large individuals need. The animals that became isolated on islands must differ somewhat from those left behind on the continent in the composition of their stock of genes, and this may have caused deviations in size from the mainland forms.

Other species of extinct dwarf elephants have been found on several Mediterranean islands and on Santa Rosa off the California coast. These species, it is generally believed, were derived from much larger continental Pleistocene forms. The Celebes elephant belongs to the same size group as these other insular forms, and the age of the large fossil Indian and Chinese elephants from which it most probably descended marks the lower age limit of the Celebes dwarf. If we only knew how much time was needed for this animal to reduce to half its original dimensions, the approximate age of the Celebes pygmy could be determined. It arrived on the island presumably 500,000 years ago. Fossil elephants were already present in this general area on Java, Borneo, the Philippines, and Japan, but van Heekeren was the first to find evidence of their existence on Celebes. The elephant somehow crossed Wallace's Line.

Of no less importance than the pygmy elephant on Celebes is a gigantic land tortoise, *Testudo margae,* a shoulder blade and several shell fragments of which were found by van Heekeren. The animal to which these remains belonged must have been between four and five feet in length and was thus about as large as the largest known recent land tortoise.

At the present time giant land tortoises are found only on some islands in the Western Indian Ocean and on the Galàpagos Islands on the equator in the eastern Pacific. The record specimen was a male individual of *T. daudinii* from Egmont Island in the Chagos Archipelago off the east coast

of Africa. Reliable testimony indicates that it had lived on Egmont Island some hundred and fifty years and had been brought over to Mauritius in 1895. It was purchased by Lord Rothschild in 1897 and died in the London Zoological Gardens in 1899. It is now mounted, with the skeleton separately preserved, in the Tring Museum in England. This specimen has a carapace length of 52.25 inches in a straight line, though larger measurements had been erroneously reported while it was alive.

In the past large land tortoises lived all over the Old and the New Worlds, but apparently they have been able to survive only on a few remote oceanic islands, on which they had virtually no enemies until man landed and began slaughtering the helpless creatures. The fossil continental tortoises of large size apparently became extinct because of their inability to cope with the larger mammals. Some of the species of *Testudo* had developed a very defective carapace and thus had lost their once-effective armor. The destruction of their eggs and young must also have been an important factor in their extinction.

Both in India and in Java we have evidence of very large fossil land tortoises in the Pleistocene; a Siwalik specimen (*T. atlas*), six feet in length, is on exhibition in the American Museum of Natural History in New York City. A specimen in the British Museum (Natural History) at London, largely reconstructed, measures more than eight feet in straight carapace length, but this is probably too large. It is not improbable that the Celebes giant tortoise is merely a dwarf descendant of this or similar continental forms. Nevertheless, the Pleistocene Celebes species represents a sizable giant, for the largest species of *Testudo* now living on Celebes is barely one half as long as the type of *T. margae*.

In addition to the elephant and the tortoise, van Heekeren found some fossil remains of pigs. Two species of the pig family are still living on the island today, but the newly discovered form, *Celebochoerus heekereni,* differs decidedly from both of them in the possession of extremely large upper tusks. In Figure 2 the upper canine of the Pleistocene Celebes form may be compared in size with that of the male wild boar *Sus celebensis*. The lower canines and also the cheek teeth of the fossil pig are not especially large, however. The relationships of this remarkable animal are still obscure; apparently no such form is known, recent or fossil, either from Asia or from Europe. The canines of the African forest hog (*Hylochoerus*) bear some resemblance to those of the Pleistocene Celebes pig, but the other teeth are very different.

FIG. 2. Right upper tusks, anterior views, of (1) the largest known recent male Celebes pig (*Sus celebensis*) and (2, 3) the Pleistocene giant *Celebochoerus heekereni*. About two thirds natural size. (After Hooijer, 1950.)

Mr. van Heekeren's discoveries also included some fossil teeth and a few bone fragments of the babirusa and of the sapiutan, or anoa, which differ from the recent forms only in their slightly superior size. It is fairly common to find Pleistocene animals, in all parts of the globe, both on continents and on islands, larger than the living individuals belonging to the same species. This fact is now generally attributed to external factors, such as changes in climate for better or for worse. Near glaciers and ice caps the summer temperatures must have been somewhat lower in the ice age than they are now. On the other hand, some meteorologists hold the view that the Pleistocene climates were in general more humid and somewhat warmer than they are at present. A world-wide amelioration of the climate since the Pleistocene would make Bergmann's rule operative, which

states that in closely related species with constant blood temperature the smaller ones inhabit the warmer climates.

Just before the present political conditions in Celebes brought van Heekeren's explorations to a most untimely end, evidence was obtained that the Pleistocene fauna of this island also contained one or two species of crocodiles (*Crocodylus* cf. *siamensis*), a sort of soft-shelled turtle, and several species of sharks, including *Odontaspis* cf. *cuspidata*. These animals live in rivers and go out into the sea, and thus contribute less to our knowledge of faunal migration than the strictly terrestrial types. All these reptiles and fishes are widely distributed, and apparently all of them have been found in the Pleistocene of Java.

Is the Pleistocene fauna of Celebes more closely related to that of China than to that of India, as the migration route would suggest? This is impossible to determine as yet, because diagnostic genera have not been found. The sun bear, hyena, and tapir, in addition to the Asiatic anthropoid apes and, perhaps, *Pithecanthropus*, have not been discovered in the Celebes collections thus far.

I have not yet discussed the stone flake makers of Celebes. The Paleolithic stone flakes found at the Tjabengè sites, a few of which are represented in Figure 3, are of the same type as those found in the uppermost Middle or Upper Pleistocene of Java and ascribed to *Pithecanthropus* or to his probable immediate descendant, Solo Man. In fact, the Celebes stone flakes are almost completely identical with those of the Javan culture. The identity of two stone cultures from different areas, however, does not prove that these cultures are of the same age. It will be remembered that even to this day we have stone age culture in New Guinea, and the Celebes culture may very well be younger than that of Java. But the stone flakes found by van Heekeren are the only evidence we have of the existence of early man in Celebes.

How did early man get to Celebes? Of course the Sangihe Islands bridge from the Philippines, which must have been used by the other land vertebrates, was available to him, too. However, it seems somewhat more probable that he made his way to south Celebes from Java. It is not impossible that the stone flake makers crossed the Randublatung Strait, which inundated part of eastern Java in the Pleistocene, and then migrated over a ridge that connected Madura-Kangean with the Spermonde Archipelago and south Celebes in the Upper Pleistocene. The strait may have impeded the migration of other land vertebrates, which most probably came from the north. In other words, the fossil vertebrates may have been of different geographic origin than the stone flakes, and their association may be purely accidental. There is no absolute evidence that man ever witnessed this most remarkable association of the dwarf elephant and

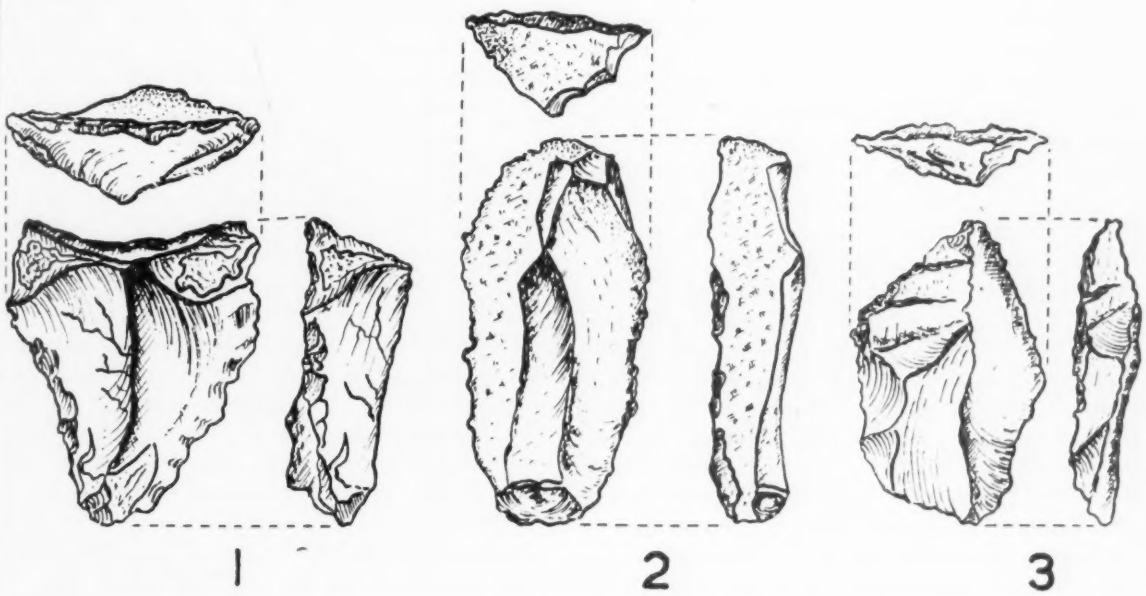


FIG. 3. Some Paleolithic stone flakes found with the fossil vertebrate remains at the Tjabengè sites in southwestern Celebes: (1) a triangular flake made of carneole with a plain striking platform; (2) a typical tool for both the Celebes Tjabengè culture and the Javan Sangiran culture, with the original cortex shown in the left-hand figure; and (3) an artifact definitely worked for the purpose of obtaining a point. Nine tenths natural size. (After van Heekeren, 1949.)

the big tortoise that lived on Celebes probably as much as half a million years ago.

The actual remains of the people who lived there and used the stone flakes must now be weathering out of the rocks in the interior of Celebes, waiting for a skilled explorer to find them. This should be the chief goal for future expeditions to this island. In Java it was a tribute to the experience of von Koenigswald that one out of every ten thousand specimens of vertebrate fossils found by his collectors belonged to a hominid. Perhaps in Celebes this ratio is somewhat more favorable.

A thorough search for vetebrate fossils in Celebes is certainly worth while, for it is very likely to disclose new or little-known animals and more perfect specimens of those already known. Van Heekeren had already located what might have been a complete skeleton of the pygmy elephant. It is to be hoped, also, that excavations can be undertaken, for these first collections of vertebrate fossils from the Pleistocene of Celebes consisted exclusively of surficial finds. We have obtained only a preliminary but most promising glimpse of the extinct fauna of Celebes, which may, upon further exploration, prove as rich and as significant as the fauna of India, Burma, China, or Java, and in comparison with which the present fauna of Celebes will be only a pitiful remnant. Here lies a wonderful opportunity for further paleontological research.

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Fourth Annual International Photography-in-Science Salon

Paul J. Ernst, Physics Department, Temple University, Philadelphia, won first prize in the black-and-white division of the Fourth Annual International Photography-in-Science Salon for his print "Ultrasonograph of Pseudo-Standing Waves in front of an Ultrasonic Lens." First prize winner in the color division was Leonard F. Belanger, of the University of Ottawa, for his print "P-32 Radioautograph of a Growing Tooth."

Other winners in the black-and-white division were: Second prize, James B. Saunders, National Bureau of Standards, for his print "Precise Topography of Optical Surfaces;" third prize, J. A. Van Allen, J. J. Hopfield, and H. E. Clearman, Applied Physics Laboratory, The Johns Hopkins University, Silver Spring, Md., for their print "Ultraviolet Solar Spectrum from V-2 Rocket," honorable mention, T. Brzeski, Polish University College, London; F. M. Cain and J. O. Mack, Carnegie-Illinois Steel Corporation Research Laboratories, Pittsburgh, Pa.; Philip O. Gravelle, The Gravelle Laboratory, South Orange, N. J.; K. Grube, L. W. Eastwood, and N. E. Winchester, Battelle Memorial Institute, Columbus, Ohio; and J. J. Hopfield, Applied Physics Laboratory, The Johns Hopkins University.

In the color division, the following also won awards: Honorable mention, Cecelia Mezowicz Ronai, General Foods Corporation Central Laboratories, Hoboken, N. J.; and Francis L. Shubert, Battelle Memorial Institute.

Judges in this unique competition for scientists and photographers, sponsored by THE SCIENTIFIC MONTHLY and the Smithsonian Institution, were A. Aubrey Bodine, of the Baltimore Sunday *Sun* (for photography); Walter F. Jeffers, of the Department of Botany, University of Maryland (for the natural sciences); Howard A. Meyerhoff, administrative secretary, AAAS (for metallurgy and the earth sciences); Merle Tuve, director, Department of Terrestrial Magnetism, Carnegie Institution (for the physical sciences); and Ralph W. G. Wyckoff, scientist director of the National Institutes of Health (for the medical sciences).

The prints will be on exhibition at the Annual Meeting of the AAAS in Cleveland, Ohio, December 26–30, and at the U. S. National Museum, January 3–31, after which they will go on tour of important scientific institutions in this country. Dates for showing the salon may be arranged by writing to the Editor, THE SCIENTIFIC MONTHLY.

Fathoms and Feet, Acres and Tons: An Appraisal

KEITH GORDON IRWIN

Professor emeritus in the Division of Science and Arts of Colorado A & M College, Professor Irwin presents here some of the results of many years of library investigation, particularly in European books for the years 1200 to 1700. Eventually these results will be given a much fuller treatment in a book manuscript, which will deal also with the evolution of weighing devices and will include forms of early thermometers, barometers, and clocks.

WHO has not heard—and, hearing, perhaps believed—that our foot rule's length was set for all time by the boot length of an early English king? And that the size of the nose of another early monarch played, somehow, a part in setting the dimensions of our yardstick? And who has not read—and, reading, perhaps believed—that an acre's length was the furrow-long strip that a certain mythical yoke of oxen was able to plow between restings? And that the acre itself was the land that these oxen could turn over with the plow in a day's time? And who has not been told—and, listening, perhaps believed—that the entire system of weights and measures in common use in this country is but a hodgepodge of diverse units, in a plan that is without logic and with little merit?

It has long been recognized that historical facts may not square with the origins suggested in legendary tales. In the case of the common measures, there is convincing evidence that arrogant and whimsical kings and robust oxen were not the prime actors that the stories have implied. Nor is there truth behind the allegation that the common units were illogical in their nature or in their interrelationships. But is one to be condemned as a believer of fairy tales if he is inclined toward disturbing thoughts as to whether these age-old measures are either adequate or desirable for a modern world, and whether a proper and wholly defensible procedure might not be to discard the old system and start anew on a more modern one? Such thoughts need not be considered either irrelevant or inconsequential. Their consideration justifies the presentation of our common system against a background of history.

The Common Measures of Length and Farm Areas against the Background of History

Our present system of measures for distances on land and sea is a direct heritage from the half-forgotten measures brought to England by the Anglo-Saxons of fifteen centuries ago. The plan they used was so remarkable for its simplicity and high practicality that we might be pardoned for seeking to credit it to Saxon genius. But the plan itself antedated by at least half a thousand years the Saxon landing on British soil, for Greek literature left an ample record of its use along the shores and waterways of southeastern Europe even in early classical times.

The basic unit of this old plan was the arm stretch, or the distance spanned by the outstretched arms. The Greeks called this the *orguia*. In Europe it became the *toise* of the French, the *faedm* of the Danes, the *fathom* of the Saxons. Races of people differ in stature. So the actual length of this basic unit varied somewhat from one racial group to another. The classical metrologists report that the Greek arm stretch in Solon's time was equal to 72.90 of our inches. In medieval Europe its length in the Rhineland was equal to 79.08 inches. With the long-armed Saxons it reached 79.20 inches. But throughout Europe the same decimal plan was used for the smaller and larger units. The nature of the completely decimalized arrangement was worked out by the scholars first of all for the classical plan, for which Greek literature gave abundant clues. Under the name of the Greek Itinerary System this plan may be found listed among the measures of antiquity. The entirely comparable old English plan as developed by England's eminent metrologist, the late W. M. F. Petrie, was worked out from such

source material as old maps, old itineraries, old laws, and the measurements of ancient buildings. In words of today the Saxon arrangement becomes:

10 finger widths	= 1 doublehand
10 doublehands	= 1 Saxofathom
10 Saxofathoms	= 1 chain
10 chains	= 1 furlong (for land measures) or 1 cablelength (for offshore measures)
1,000 Saxofathoms	= 1 "thousand" (the old English sea-and-land mile)

Farm lands were laid out in a similar simple way:

A block of land 100 Saxofathoms wide by 100 Saxofathoms long	= 10 acres
As this land would be plowed lengthwise,	
A strip of land 10 Saxofathoms wide by 100 Saxofathoms long	= 1 acre

The Saxofathom, as a unit of length, has long since disappeared, being outlawed six centuries ago in favor of a shorter fathom. Yet that ghostly arm stretch is still the basic measure for the farm lands of an English-speaking world. A modern contrivance for measuring small acreages has, perhaps unwittingly, restored for the moment the old Saxon measures and the simplicity of the old plan. Because it has done so, the contrivance is worth describing. Made of light material and triangular in form, it has a waist-high handle for the apex of the triangle and a strip of wood for the base. At either end of the strip, and jutting down a few inches, is a rounded peg. From center to center the pegs are 79.20 inches apart. This number is important, for it is the exact length of the old Saxofathom. The main measure is divided, on the baseboard, into 10 equal parts, and each of these, again, into 10 equal parts. These divisions correspond to the doublehand and finger-width units of the old plan. When in use the device is given a whirling, end-for-end motion as the operator walks down the boundary of the field he is measuring. For a square 10-acre field the count should be 100 Saxofathoms for width and the same for length, and the report is that even an inexperienced operator will not miss these results by more than an inch or so. For fractional acreages or plots of ground not dimensioned in any exact Saxofathom manner, the scale upon the base of the device is called into play, any part of the main unit being represented as a decimal fraction. For fields laid out with square corners the acreage is found in all cases by multiplying together the length and width, as measured in Saxofathoms, and dividing the result by 1,000. The plan is that of the Saxons. The use of the decimal point, if one is needed, is the only part of the plan that is modern.

Had the men of that long-ago time in England not been such tall men, with such a great reach of arm and long stride, a second development in English measures would certainly have followed a different course and a simpler one. In the year 1066 Saxon England was conquered by the Normans from across the English Channel. In the following centuries Norman castles took the place of the simple fortified homes of the Saxon thanes, and abbeys and Gothic cathedrals were reared on the sites of earlier church structures. Skilled workers were needed for this construction—workers in carved wood and fashioned stone, forged metal and shaped glass, embossed leather and embroidered tapestry. Such craftsmen, brought to England from the continent, were, in general, shorter in stature than the fair-haired, blue-eyed Saxons. As the Saxofathom was too long a distance for their outstretched arms to span, their measures, of necessity, were based upon shorter lengths. At first the units adopted by one craft may have had no close agreement with those of other crafts. And there must have been trouble between the various craft groups, between the hewers of wood and shapers of stone who knew only Saxon measures. A compromise plan was imperative if confusion was to be avoided.

About the year 1250 such a compromise plan was developed; by 1350 it was in virtually universal use in all but the most rural districts of England. This plan set up a *new fathom* exactly 10/11 as long as the old Saxofathom. This new unit was divided in half to get the clothmaker's *yard,* and into 6 parts for the craftsman's *foot.*

The new fathom met with no special objection from those who held the lands of England. The acre, of course, was no longer to be referred to as 10 fathoms by 100 fathoms in size, for the fathom itself had changed. It was now 11 new fathoms by 110 new fathoms. The plan had lost part of its decimal simplicity, but the boundaries of the acre were intact. And the rod—a common measuring stick of 2 1/2 Saxofathoms—was not changed in length, though new notches were to be cut on it to mark off its length into sixteen 1/2 feet. The furlong was also intact. But for some reason the old mile of 10 furlongs was discarded. For it there was substituted a *statute mile* of 8-furlong length. This meant for the square mile of farm land a drop from 1,000 acres to 640 acres.

Of the subordinate units of the old plan, a few had to be forced out of existence to prevent confusion. Thus the old yard was legally abolished to make way for the new one, which was 10/11 as long. The finger width also gave way to the inch. For the hand—as a twentieth of the Saxofathom—there was a different fate. By a mere 1 per cent in

crease in size it was to fit into the new plan as a 4-inch measure. Thus only a few changes were made in bringing the craftsman units into accord with those of old England, and none of these affected land areas or invaded property rights. Yet the full consummation of the shift of measures, small as it was, stretched almost across two centuries.

In 1624 an attempt was made to restore the simplicity of the Saxon plan for farm measurement. Edmund Gunter, a practical English mathematician, proposed in that year an arrangement of measures that by-passed the old Saxofathom and reintroduced the old double hand under the name of link. If we include the finger width as the smallest unit, we may write the Gunter plan as:

10	finger widths	= 1 link
100	links	= 1 chain
10	chains	= 1 furlong
10	square chains	= 1 acre
1	square furlong	= 10 acres

On the practical side, Gunter devised for the surveyor a skillfully constructed chain with 100 equal links. With the aid of such a chain the surveyor could measure farm areas rapidly and accurately and report the result in simple, decimalized units. George Washington, as a young man, used Gunter's equipment and plan, as did all American surveyors from Washington's time almost to our own.

The Gunter measures did not gain common acceptance among farm people, for the plan neglected that versatile measuring unit of the farm, the rod. To the surveyor an acre would be 10 square chains of land; to the farm user it would be a block of land 4 rods wide by 40 rods long, or its equivalent. To that extent, the Gunter attempt to restore the decimal simplicity of the old measures fell short of accomplishment.

In Saxon days there had been no difference between the length-measure plan as used for distances on land and for distances out from the shore except that the furlong of the landsman was the cable length of the seaman. The sea and land plans were to diverge, however, when the new fathom was adopted. The men of the sea were to retain the old system in its entirety, cutting all units to 10/11 their former size, in keeping with the change in the fathom. This meant that the sea mile of 1,000 new fathoms was, after this, considerably longer than the 8-furlong statute mile used for land measurement.

Some centuries later, a small but highly important change was made in the sea mile's length. By that time the ocean navigators had discovered that the length of a minute of arc on a great circle of the earth was slightly more than 1,000 fathoms. By increasing the sea mile to 1013.4 fathoms, the two would be brought into coincidence. In time this change was adopted officially, the new length becoming the *nautical mile* of the seaman, or the *geographical mile* of the cartographer.

As the result of these several stages of development, each entirely logical in itself, the English system of length and surface measures came to be not a single plan but a composite of three interwoven designs. The old English part had given the English-speaking nations their farmland unit of the acre and the statute mile. The craftsman part had contributed the yard, the foot, and the inch. The distance-at-sea part had furnished the nautical mile. And the units so developed may not readily be changed. The farms of the British nations and the United States would seem to have imposed an unbreakable rigidity upon the size of the acre. The foot that received its length when there were few crafts has, today, embroidered around it the workday measures of a thousand occupations. The size of the nautical mile is fixed by the very earth itself.

The Metric Measures against the Background of History

We shall now need to turn our attention to a modern plan that was devised to eliminate the more pronounced disadvantages inherent in such older systems as that of England.

In the decade that followed the American Revolution the use of decimal fractions took on practical importance. In the money system devised for our newly established country these fractions when used with decimalized money units made a combination that was startling in simplicity and usefulness. To carry this same idea to the whole field of measurement became the dream of scientists and others the world over.

Only a French Revolution could have brought such scientific dreams so swiftly to fruition, for that period was one of those rare times in history when old standards were swept away, without a word of protest, to make room for new ones carried on a wave of high idealism. There was no compromising, no counting of costs. Many of the plans pressed so urgently by the savants and accepted so enthusiastically by the revolutionary assembly were not, however, to become a permanent part of the structure of French measurement. The ten-day week ran too counter to human requirements to gain more than a transitory existence. The decimalized plan for the hours of the day and the new form in which the year's calendar was cast met a like fate. And so did the plan for measuring the earth in a new kind of

degree—though the failure here was related to the international scope of the plan and the puny effect that the decisions of a revolutionary assembly of France would have in dictating the measures of a world. The plan itself proposed that the old method of dividing a quadrant of the earth into 90 degrees, with each degree marked off into 60 minutes of arc, be changed to give each quadrant 100 new-sized degrees and each of these, 100 new-sized minutes of arc. Although this novel plan soon passed into oblivion, it was to leave a permanent imprint on another part of the over-all plan, as we shall see.

The plan developed for the handling of measures and weights, unlike most of the others, was to outlast the French Revolution. It was intended to be ideal both for land and for sea, and its final form was a modernized version of the English nautical mile plan and that of the old Saxon-Teutonic sea-and-land system dovetailed to give a single composite. For all its attempt at high practicality, this French, or metric, plan was to fail at a point where success seemed most certain. And a chance factor was to prove of outstanding importance in its acceptance.

In the sea part of the plan, there is a close basic relationship between the metric measures and those of England. The nautical mile, as has been pointed out, matches the length of a minute of arc on a great circle of the earth. The "metric mile" was devised along the same line of reasoning. It was to match the length of a hundredth of a hundredth of the earth's quadrant, following the idea of the new-sized degree and new-sized minute of arc, whose existence in a sort of blueprint stage we have already mentioned. Just as a thousandth of the nautical mile was (very nearly) a fathom, so a thousandth of the "metric mile" was to be (exactly) the length of the new French basic measure to be known as the meter.

This "metric mile" (later christened the kilometer) was, by nature of its relation to the size of the earth's quadrant, 540/1000 as long as the English nautical mile. That it failed as a useful sea measure may not be charged to any gross error in the measurement of that part of the earth that this unit was to represent. It came, instead, from the evanescent nature of the new-sized degree upon which its length had depended. Today in metric countries the same nautical mile is in use as in the rest of the world, this length of a minute of arc on a great circle appearing, quite awkwardly, as 1,852 meters.

The newly devised measures were, however, successful as land units. This was not through design. It was due to a chance relationship, to the fact that the meter was half as long as the old north-Europe fathom. This ancient arm-stretch unit, which, among the Saxons, was the basis for all measurements on land and waterways, had its counterpart in the measures used by the Teutonic tribes that invaded the continental Roman provinces with the collapse of the Western Roman Empire. It was in terms of these fathoms that the captured Roman lands were laid out anew. There was, it is true, a little variation from tribe to tribe in the length of this almost universal measure. The Saxofathom was a little longer than most of the others. Its length, as mentioned previously, was that of 79.20 present-day inches. For the districts along the Rhine the corresponding length was 79.08; for some parts of France it was 78.24, and for Spain 78.98. Strike an average of the last three and you have 78.77. Double the length of the meter and you have 78.74. The similarity is startling. It seems much too close to be the result of chance. But upon that accidental relationship was to rest much of the acceptance of the metric system as a land measure for continental Europe.

The importance of that relationship may, perhaps, best be shown by placing the metric plan of length beside the well-decimalized Saxon system. Had the meter been *exactly* half as long as the Saxofathom it would necessarily follow that every Saxon unit of length from the finger width to the old English mile would be matched, unit for unit, by a metric measure of half its size. Extended to farm land, a block of ground that measured 100 Saxofathoms by 100 Saxofathoms would be 200 meters by 200 meters. In Saxon terms that much land would be 10 acres, in metric 4 hectares. Even the English statute mile, though not a part of the original Saxon plan, would fit into the simple scheme of relationships. Its length of 8 furlongs, or 800 Saxofathoms, would be equal to 1,600 meters.

In the average American the relation of Saxon and metric measures that we have pointed out will arouse no particular interest. Propose to him that we could secure international uniformity in the matter of land areas by cutting down our 10-acre fields to 4-hectare size and our miles to 1,600-meter lengths, and he may but shrug his shoulders. He wants to know how much would have to be pared off. Tell him that it would amount to but 3.83 feet for each dimension of the 10-acre block and about 30 feet for the mile, and he may reply that 30 feet is almost as wide as a country road. You argue that this small change would make our measurements agree with those of continental Europe and the Americas to the south of us, and he responds, "If they really want unity that much, let them up the meter a bit to match what we have to offer." He

does not consider himself a reactionist or a blockader of progress. His answer represents, to him, simply common sense.

The Background for the Common and Metric Units of Weight

Up to this point we have followed only the story of the development of measures of length and surface. We should speak somewhat briefly of other units as well.

It has often been implied that the plan used by the founders of the metric system in arriving at weight units was unique. On the contrary, all comprehensive systems of measurement and weight from the time of Solon in ancient Athens down to the present appear to have used it. It would be more logical to stress the point that in the metric plan the relation of small weights to each other or to large weights was in every case a decimal one.

How the gram-weight of the metric system was to represent the weight of a cubic centimeter of pure water at a temperature of 4 degrees Centigrade is doubtless familiar to everyone who has studied the physical sciences. How the English craftsman obtained the weight of the pound is seldom told. This weight unit came into general use in England in the relatively brief period between the years 1300 and 1333. As may be judged from internal evidence and from a knowledge of similar methods used elsewhere in Europe, the English plan was to set the weight of a cubic foot of water equal to 1,000 "ounces," that of 16 cubic feet of water equal to 1,000 "pounds." The metric plan was to parallel the other, but with a more complete decimalization, when it set the weight of a cubic decimeter of water equal to 1,000 "grams," and the weight of a cubic meter of water equal to 1,000 "kilograms."

It is always far easier to prepare accurate replicas of a standard weight than to develop the standard itself from volume measurements, a fact that has been recognized since Solon's time. The original standard establishing the legal size of the pound was placed in the English Exchequer in the time of Edward III. A new standard, conforming to the original one, was prepared in the reign of Queen Elizabeth. Although neither of these is in existence now, close replicas of Elizabeth's pound constitute the standards of today in England and the United States. Whatever may have been the case in the earlier standards, those of today are too heavy by half a drop of water per ounce, if the cubic foot of water used in checking the weights is measured under the same refinement of conditions specified for metric weights. The error, which amounts to 8 parts in 6,992, or 11/100 of 1 per cent, may have been introduced in connection with Elizabeths' standard. It appears reasonably certain that her advisory committee suggested that the weight of the pound should, for commercial convenience, be made equal to 7,000 troy grains. For pure water at a temperature of 4 degrees Centigrade, the correct value is exactly 6,992 grains.

The similarity in basic plan between the cubic foot of water and the ounce, on the one hand, and the cubic decimeter (or liter) and the gram, on the other, explains certain relationships between English and metric measures that have been noted by technical and scientific workers. Thus, the weight of a liter of a gas as given in grams matches in number value that of a cubic foot of the gas as recorded in ounces. Also, the specific gravity of a solid or liquid has a numerical value that is the same as the weight of the solid or liquid in grams per cubic decimeter, or the weight in ounces per cubic foot, if these weights are divided by 1,000. For example, the specific gravity of mercury is 13.6; a cubic decimeter of it weighs 13,600 grams; a cubic foot will weigh 13,600 ounces. Or the weight of moisture present in a sample of air will be expressed by the same number whether given in grams per cubic meter or in ounces per thousand cubic feet. Or a solution of a certain strength may be made either by adding the required number of grams of the material to make up a liter of solution or by using the same number of ounces in making up a cubic foot of solution. Such similarities can be almost endlessly extended, but always, it should be noted, the results will match only to three figures, for there is an inherent error in the English plan of 8 parts in a total of 7,000.

Our Wine Measures

The pint and gallon that we use for liquid measures are not, by their nature, comparable either to the cubic foot or to such metric measures as the liter. They represent wine measures set up under legislation for the wine-handling trade. The tun, a large unit not mentioned in a direct way in the early English laws, was the quantity of wine that in a vat measuring 4 feet by 4 feet on the inside would fill it to a depth of 25 inches. This much wine was considered to weigh 2,000 pounds. Since wine has an average specific gravity very close to 0.96 for wine-cellar temperatures, the results were always close to the 2,000-pound estimate. The basic small unit of this wine plan was the pint, a measure that was 1/2000 of a tun and so would hold a pound of wine.

In later times many commodities other than wine

were, at one time or another, measured out in "pints"—that is, in capacity vessels of an assortment of sizes each designed to hold a pound of a certain kind of commodity. The Queen Anne bushel, which has been in use with us since colonial times, is an example of a 64-pint measure set up for grain.

During the nineteenth century the British Empire, plagued with a multiplicity of such "pints," swept away the wine measures, the Queen Anne bushel, and a variety of other capacity devices, replacing them by a single system in which the imperial gallon, a new unit, was to have the volume of 10 pounds of water and the new bushel was to be 8 imperial gallons in size. The plan stopped short, however, of being adequate from a modern point of view. It failed to make the pint the volume of a pound of water, with the pint divided decimally into smaller units. These two points were important.

Our pint and gallon are not adapted to general work with liquids to the extent that the British imperial gallon and the metric liter are. It should be noted, however, that our pint is basically defined in terms of water, for it was to be a vessel holding one pound of a liquid whose weight (as indicated by the specific gravity) would be 96/100 that of water. It would follow then that 96 pints (12 gallons) of water would weigh exactly 100 pounds, and a sixteenth as much, or 6 pints of water, would weigh exactly 100 ounces. These values are completely correct for temperatures close to 60 degrees Fahrenheit, or wine-cellar conditions. Even the Queen Anne bushel is not so bizarre in its capacity as the legal content of 2150.42 cubic inches would imply. It is exactly 56/45 of a cubic foot in size; so 45 bushels of grain will just fill a bin whose inside measurements are 7 feet by 8 feet by 1 foot.

The tun of wine as a liquid capacity measure seems always to have been matched in the early days of the wine measures by the idea of a tun weight of 2,000 pounds, which is what such a quantity of wine would weigh. Given a more modern spelling and now applied to commodities in general, this weight unit is our 2,000-pound ton. And tunnage, or the number of tuns of wine that a boat might carry, is now tonnage and represents any load or cargo measured in tons.

Another tun-weight idea was in use, from the beginning, among seamen. It was a gross weight taking in the weight of the tun of wine and the containers for the wine. Whether the liquid was handled in barrels or casks, 12 pounds of container weight was estimated as being required for each 100 pounds of wine, or 240 pounds for each 2,000 pounds of wine. This gross ton of 2,240 pounds soon became fixed for all commodities carried by ships. Its continued use has long resulted in a moderate amount of confusion.

Troy and Apothecary Weights

Not long before the development of the English weight plan, the thriving Italian cities of Venice, Florence, Genoa, and Milan had set up an integrated plan of a similar nature to fit their commercial needs. And the same had been true of the group of federated cities along the Rhine, the North Sea, and the Baltic known as the Hanseatic League. For all three—England, the Italian communes, and the Hansa cities—the weight units were derived from the weight of a cubic foot of water. England, as we have noted, divided the weight of their cubic foot into 1,000 ounces. The Hanseatic League split the weight of its somewhat larger cubic foot into 1,000 *onzen*. The Italian cities with a still larger basic cubic foot divided it into 1,333 1/3 *onzia*. The result was an English *ounce* of 437.5 grains, a Hansa *onze* of 480.0 grains, and an Italian *onzia* of 436.2 grains.

The *Oxford Historical Dictionary* suggests that the abbreviation "oz.," as used for the common ounce, is, in reality, that of the Italian *onzia*. The difference between 437.5 and 436.2 grains was evidently so slight that the two weights must have been considered commercially equivalent for ordinary weighing.

The Hansa *onze*, nearly 10 per cent heavier than the other two, was known in England as the troy ounce. This weight unit dominated the commercial dealings of Western Europe during the ascendency of the Hanseatic League, for the weighing of silver and gold, as well as for drugs and luxury items which, coming from the East, were distributed by the merchants of the Rhineland cities. By the close of the reign of Elizabeth of England the prime importance of the Rhineland *onze* and its companion weights of the drug trade was dwindling. Bitter religious wars had obliterated old trade routes. The products of India, China, and the Spice Islands were reaching Europe by cargo ships that ran directly to the cities that faced out on the Atlantic. There were new sources for silver and gold, and new weight systems for their handling.

By the end of the nineteenth century the troy and apothecary weights which, in an earlier day, had been raised by the Hansa cities to a position of international importance had vanished in all countries but our own. The metric countries had built their pharmacopoeia around metric units. The British had abolished all the old weight units of these two systems except the troy ounce, using it

only in the minting of coins. Even in the United States there has been a gradual shift away from the old apothecary weights to metric ones in the filling of prescriptions and the compounding of medicines, and to common weights in wholesale drug handling. It is not improbable that another decade may see the end of the scruple and the drachm. Perhaps the "fine ounce" may be gone as well. They have all outlived their usefulness.

Modernizing Changes of the Past Three Quarters of a Century

This brings the story of the development of the English and metric units down to the year 1870. The English system was, by that time, half a thousand years old; the metric system had not yet spanned a century. But neither had as yet reached a condition of immobility. Thus in the decade following 1870 we find the metric system being improved for scientific purposes through the concerted efforts of an international group of scientists. New definitions were set for the meter, kilogram, and liter, and smaller units were added to the original plan. It was in this period that the meter changed its status from a French measure to an international one.

From that same period of time modernizing changes began to be applied to the common units, most of the modifications being along the line of decimal-fraction handling of the foot, inch, and pound. Thus the new engineer's chain, supplanting Gunter's chain for surveying and land measurement, was 100 feet long, with the foot divided decimally. Before the turn of the century the micrometer, a device that could be used to measure the parts of a machine to the hundredth or even thousandth of an inch, had been added to the mechanic's list of indispensable tools.

The shift to decimal dimensioning has been largest in the metal trades. In this connection we have the report of S. B. Elrod, of Purdue University, at the 1948 meeting of the American Society for Engineering Education:

> Fractional dimensions are giving way to decimal dimensions. The two place decimal system inaugurated by the late Carl E. Johanssen, in the Ford Motor Company plants, has gained ground rapidly and is used by most of the automotive industry and over 80 per cent of the aircraft industry. The system has the advantages of the metric system without requiring a re-educational and re-tooling program. Surveys conducted periodically show the shift to decimal dimensions continues steadily.

With us another movement has also been under way that is directly related to the idea of modernization. By the turn of the century, or shortly after, many devices had been perfected that could measure or weigh in an automatic and highly accurate manner, the results being reported to decimal-fraction parts of the unit used. There were odometers to measure the length of trips, chronometers to read time intervals, and vending machines to report on gasoline supplied and its cost. All were practical, all were illustrative of the ease with which decimally divided units can be handled in measurement and in calculation.

But something more than decimal dimensioning and mechanical devices is needed to give a real modernization to the common plan. As in the metric system, well-named large and small units are needed within the framework of the decimalized main measures of length and weight. Strangely enough, the know-how needed to design a machine that automatically measures liquids to thousandths of a pint, determines to the nearest pound the weight of a load of coal, or carries out the thousand and one things demanded of weighing and measuring devices does not include the know-how for the production of a modernized plan built about the common units. Nor have the engineering schools or industry itself presented a program that might effect such a plan, though each has made some contribution to the emerging pattern of modernization. Considering the present status of our capacity measures and the difference in such measures as used in this country from those of other English-speaking countries, it may be considered surprising that the more thoughtful representatives of engineering and industry have given but nominal approval to the proposed substitution of the "pound-pint," or volume of a pound of water, for all other pints. By replacing our present wine pint and grain pint with such a pound-pint, and fitting it into the framework of the imperial gallon and British bushel, we could achieve a capacity plan having both logic and practicality. With such a plan we may envision a day when the kilopint and millipint of the English-speaking world would become the useful measures that the kiloliter and milliliter are for the metric countries.

The Possibility of World Unity in the Matter of Measures and Weights

Even a well-modernized treatment of the common units cannot be expected to result in a plan that would equal that of the metric system. As a younger system, the metric units had a greater over-all simplicity of relationships. The weight standards were more accurately constructed. Each main unit was the center of a decimalized arrangement of both large and small secondary units, for which a simple and consistent naming plan had been developed. These things made it the best that

the human mind could conceive and the human hand construct.

In 1866, by act of Congress, the use of metric units was legally sanctioned in this country. This meant that a duality of measures would, after that date, be permitted. And it was freely predicted that the meter, liter, hectare, and kilogram would soon supplant, in a competitive way, the foot, pint, acre, and pound of the older system. This prediction was based upon two premises: the appeal that an international system of measures and weights might be expected to have for the liberal-minded thinkers of America, and the practical advantages of the metric system itself.

The results were highly disappointing. America was definitely not international-minded. And the practical advantages were considered nebulous by a people whose life activities had been geared to the common units. Thus the farm population could see no advantage in the use of the hectare and kilometer over the acre and the mile that would justify the effort involved in making the change. Within the home a somewhat similar condition existed. Such craftsman units as the yard and foot had been built about the height, the arm-stretch, and the stride of men. And the American home, reflecting the life of the people who lived there, had used these units for the sizes of rugs, the heights of ceilings, and the dimensions of furniture and other equipment. It was quite understandable, then, that the housewife would discover no advantage in substituting the unfamiliar and awkwardly long meter for the homely, useful units about which her home and its life had been developed. Likewise in the shop the American worker discovered no advantage in the centimeter over the inch, as a small unit of length, that would justify the redesigning of the machinery in the shop to give whole-number dimensions in centimeters or millimeters for such things as bolts, steel thickness, gears, and shafting.

None of the population groups that we have mentioned—the farm people, the housewives, and the workers in the shops—had considered the metric system as a whole. Each group condemned the new system as impractical because it failed to offer advantages in some limited field. There is a reverse side to the picture. Gains have been made for metric units in such special areas as the scientific laboratory, where the handling of small lengths, volumes, and weights is almost universally done in such units. Even operational plants that handle raw materials by the ton or gallon may have a laboratory equipped only with metrically calibrated apparatus. In the field of machinery manufacture, the producer of scientific equipment normally makes products fitting whole-number metric dimensions. Those producing general equipment intended for metric countries may follow the same policy. But for the vast majority of the factories which, in this country, are producing tools and machine products for the American public only common-unit dimensioning will be used. To do otherwise would lose a hundred customers for one that might be gained. And the same general idea extends to all the major fields of human endeavor in the United States.

For many of us it is with reluctance that we acknowledge that our dream of world uniformity in weights and measures is, after all, but a dream. To be sure, England, centuries ago, shifted from the agrarian measures of the Saxons to the industrial measures of the craftsmen, and did it without devastating effects. But the units of the old plan and the new were fully commensurate, no property lines were affected, and the industrial workers were convinced of the need for the change. Any attempt to install the metric system in present-day America, supplanting the common units in a legal way, would be favored by none of the factors that supported the change to craftsman units. We may, of course, point out that France made such a shift and emerged successfully. But our present situation does not parallel that of France toward the close of the eighteenth century. Previous to the adoption of the metric plan that country was without any unified, national system. Several length standards were in use, each supreme in its own area. The weight units, though quite uniform throughout France, needed drastic redesigning. They represented the thousand-year-old coinage weights of Charlemagne, for which some worn coins of old Byzantium had been the model. For this peculiar combination of measurement ills the introduction of metric values could have the desirable effect of a compromise plan, not far out of line with old measures, yet capable of sweeping away all the old outmoded or conflicting standards. A somewhat similar set of conditions was present at the time of the establishment of the German Empire in 1871. The somewhat variant measure and weight standards of the numerous kingdoms, principalities, and duchies that were combined in empire formation were brushed aside, the meter and kilogram, as compromise units, taking their place.

For the system of common units found in this country and other English-speaking nations there is present no mixture of rival measures that would call for eradication, no desperate need of a compromise proposal whose forceful adoption could bring order to a chaotic situation. No parallel to a France or a Germany exists.

In an indirect way the adoption of the metric system by continental Europe was to improve the situation for those countries which, like our own, use the foot, the acre, and the pound. By eliminating the older measures of that continent that went by the name of foot and acre and pound, the widespread metric adoption left the world with but one foot and one meter, one acre and one hectare, one pound and one kilogram.

Thus we conclude our report on the origin and development of the English and metric systems. With such a background we should be able to make some rather reliable predictions as to the future.

The history of the past would seem to justify with certainty the following aspect of the future. These two systems—English and metric—that today dominate so completely the industrial world will continue, side by side, as the giants of the world of tomorrow. Neither has been able to absorb the other—a situation that will not change in any foreseeable future.

On a second point there would seem to be equal certainty. The common system is still in the process of change, with the future offering ample opportunity for further modernization.

New Books Received

[*Continued from advertising page vi*]

Ion Exchange Resins. Robert Kunin and Robert J. Myers. xi + 212 pp. Illus. $4.75. Wiley. New York. 1950.

The Incomparable Valley. François E. Matthes. Ed. by Fritiof Fryxell. xiii + 160 pp. Illus. $3.75. University of California Press at Berkeley. 1950.

Beitrage Zur Gesellungs- und Volkerwissenschaft. Richard Thurnwald. viii + 476 pp. DM 25. Verlag Gebr. Mann. Berlin. 1950.

Textbook of Organic Chemistry. Louis F. and Mary Fieser. viii + 741 pp. Illus. $6.00. D. C. Heath. New York. 1950.

Diseases of Cereals and Grasses in North America. Roderick Sprague. xiii + 538 pp. Illus. $7.00. Ronald Press. New York. 1950.

Bees. Karl von Frisch. xiii + 119 pp. Illus. $3.00. Cornell University Press. Ithaca, N. Y. 1950.

Faunal Lists and Descriptions of Paleozoic Corals. (Memoir 44.) R. S. Bassler. ix + 315 pp. Illus. (No price given.) Geological Society of America. New York. 1950.

An Outline of Scientific Criminology. Nigel Morland. xiii + 284 pp. Illus. (No price given.) Philosophical Library. New York. 1950.

Superfluids. (Vol. 1.) Fritz London. viii + 181 pp. Illus. $5.00. Wiley. New York. 1950.

The New You and Heredity. (2nd ed.) Amram Scheinfeld. xii + 616 pp. Illus. $5.00. Lippincott. New York. 1939, 1950.

Probability Controls. Robert Kirk Mueller. xvi + 310 pp. Illus. $5.00. Modern Industry Books. New York. 1950.

Pharmacological Basis of Penicillin Therapy. Karl H. Beyer. xv + 214 pp. Illus. $4.50. Charles C Thomas. Springfield, Ill. 1950.

Methods in Medical Research. (Vol. 3.) R. W. Gerard, Ed. xii + 312 pp. $7.00. Yearbook Publishers. Chicago. 1950.

Technological Applications of Statistics. L. H. C. Tippett. ix + 189 pp. Illus. $3.50. Wiley. New York. 1950.

Color Atlas of Pathology. Prepared under auspices of the U. S. Naval Medical School, Bethesda, Md. xi + 546 pp. Illus. $20.00. Lippincott. Philadelphia. 1950.

Laws of Motion in Medieval Physics

ERNEST A. MOODY

A student of the logic, physics, and philosophy of the later Middle Ages and early modern period, Dr. Moody carries on his research as associate professor of philosophy at Columbia University. He has recently completed an extensive investigation of the medieval background of the dynamics utilized by Galileo. This article represents some of his gleanings from medieval documents.

PHILOSOPHERS have discussed motion ever since the days of Thales (*ca.* 585 B.C.), seeking to explain it in terms of unchanging eternal causes. Modern physics has been less ambitious, but more successful, through seeking only to discover invariant functional relations between certain measurable factors involved in motions. These factors are, fundamentally, *distance, time,* and *mass.* As occurring in the general laws of motion, however, these factors appear in the form of differential expressions such as *velocity, acceleration, force, momentum,* and *kinetic energy,* representing elementary displacements of mass particles in infinitely small lapses of time. Without the procedures of differentiation and integration provided by the calculus, generalized laws of motion, exhibiting the invariant relations underlying the enormously complex and varied phenomena of movement and change, are scarcely attainable. The history of mechanics, or of man's effort to bring movement and time into the domain of mathematical order and intelligibility, has been in large measuse the history of man's progress toward discovery and use of the infinitesimal method.

Modern mechanics is generally said to have been founded by Galileo (1564–1642). He is credited with the first clear and conscious enunciation of two fundamental principles of mechanics. One of these is the principle that a *force,* and in particular the force that we call "gravity," is to be measured by the *acceleration* of the body on which it acts, and not by the simple velocity of the body. The second principle, essential as a means of determining the value of a force from measurements of finite displacements of bodies through measurable periods of time, is the kinematic law which relates distances traversed to time elapsed in uniformly accelerated movement. These two basic principles are expressed in the familiar equations of our physics books: (1) $F = m \cdot a$, and (2) $s = \frac{1}{2}a \cdot t^2$. In developing these laws of motion Galileo acknowledged no predecessors or sources. The only theory of motion of which he took account was that of Aristotle, and his whole effort was to refute Aristotle's theory.

Until the present century, historians of science have taken it for granted that Galileo did not have any predecessors of importance, and that the Aristotelian dynamics had been uncritically accepted throughout the entire medieval period. Due in large measure to the pioneer historical studies of Pierre Duhem,[1] it is now known that this assumption was mistaken. The Middle Ages developed a mechanics of its own, in criticism of that of Aristotle; and this mechanics contained many ideas and methods, as well as some of the basic laws of motion, that entered into the structure of the physics of Galileo and Newton. We shall here consider the contributions made by fourteenth-century mathematicians and physicists who worked at the universities of Oxford and of Paris, which have direct bearing on the development of the two basic "laws of motion" already mentioned. The kinematic contribution was made first, at Oxford, and the development of the dynamic analysis took place only slightly later at Paris. In both cases, the starting point of the new formulations was dissatisfaction with the treatments given by Aristotle and his commentators to the problem of local motion. The Aristotelian doctrines were not branded as false, but they were criticized on grounds of obscurity, inadequacy, or inconsistency. The atempts to remedy these defects nevertheless turned out to undermine the whole Aristotelian formulation of the problem, and to replace it with a radically new mechanics.

To understand the medieval contributions we must examine the basic law of motion proposed by

Aristotle. In the seventh book of his *Physics* he set forth three rules governing the proportions of distance, time, motive power, and resistance, in rectilinear displacements of bodies acted upon by an external mover. His law may be expressed, in general form, by the statement that the ratio of distance traversed to time elapsed varies directly with the motive power and inversely with the resistance. Letting F represent force, or "motive power," R the resistance, s the distance, t the time, and k a constant depending on the metrical units chosen, Aristotle's law takes this form: $F/R = k \cdot s/t$.

An important restriction is made on this law by Aristotle; namely, it applies only within the class of cases where the motive power F is greater than the resistance R. Where force is equaled by the resistance, there is no movement. This restriction indicates that Aristotle conceived resistance in the manner of an opposed force, as would be exemplified in the case of two weights on opposite arms of a balance, the heavier being the "mover" and the lighter one the "resistance."

A second point to be noted is this: Aristotle does not treat the ratio s/t as a differential rate of displacement in each infinitely small part of the time of the motion; he interprets t as representing the whole time of the movement, and s as representing the whole distance traversed. This leaves open the question of whether, *within* that period of time, the body is moved at a constant velocity, or at a constantly changing velocity. Presumably Aristotle understood such motions to be at constantly changing velocity, since he held that rectilinear local motions are either "natural" or "violent," and that both kinds are normally at constantly changing speed.

The principal obscurity in Aristotle's law is offered by the term "resistance." In this he includes friction, the density of the medium through which the body is moved, and, where the movement runs counter to the "natural" motion of the body, its heaviness or lightness relative to the medium in which it is moved. Mass, in the modern sense as resistance to acceleration, is not distinguished from the other types of resistance, though it is perhaps understood in a vague way as constituting the resistance offered to the motion by the corporeal medium.

It is clear that Aristotle's law, though plausible as a formulation of the special case of weights connected by a lever or pulley arrangement, is a gross oversimplification of the problem of the local motions of bodies in general. It presents insuperable difficulties when applied to the cases of free fall of heavy bodies, or of the movement of projectiles. More particularly, in its neglect of the whole question of how moment-to-moment velocities are related *within* the whole time of the movement, Aristotle's law permits of no consistent application to all kinds of local motions. The radical shift from Aristotelian dynamics to modern dynamics, initiated in the early fourteenth century, involved two essential steps: (1) A kinematic analysis in which motions at constant velocity are distinguished from motions at changing velocities, requiring the concept of "instantaneous velocity" and a method of differentiation and integration of velocities as functions of time; (2) a reinterpretation of the concept of "resistance," whereby it is conceived as resistance to acceleration, entailing a reinterpretation of "motive power" as that which acts to *change* the velocity of a mass. Let us now examine the beginnings of these two developments in the early fourteenth century.

II

The leading mathematician of the early fourteenth century was Thomas Bradwardine (1290–1349), who was active as a teacher at Merton College, Oxford, up to the year 1335. Merton College was the leading center of mathematical studies in all of Europe during this period. It was here that John Maudith produced the first Western treatise on trigonometry in 1310. Bradwardine, who had himself done important work in pure mathematics, wrote a treatise in the year 1328 in which he attempted to employ a strictly mathematical method in the field of dynamics. His treatise was entitled "On the Proportions of Velocities in Motions."[2] In a brief preface, he stated that although philosophers had disputed about motion for centuries, and had asserted that velocities are in some way proportional to motive powers and resistances, none of them had shown, by mathematical means, just what kind of proportionality is involved.

In his first chapter Bradwardine reviews the Euclidean theory of proportion, and makes evident the vast difference between arithmetic and geometric proportionality. In his second chapter he examines and criticizes several "erroneous" theories or laws relating velocities to forces and resistances, and in his third chapter he sets forth the "true theory." Of the theories criticized, only two are of interest. One of these is the law of simple proportionality, which we have attributed to Aristotle and which is represented by the formula $F/R = k \cdot s/t$. The other is a modification of the Aristotelian law derived from the Arab philosopher Ibn-Badga (Avempace), which may be represented by the formula $F - R = k \cdot s/t$. We shall here consider only Bradwardine's criticism of the Aristotelian law and the reformulation he proposes.

Bradwardine accepts two basic assumptions made by Aristotle as conditions which must be satisfied by the general law of motion. First, it is postulated that motion occurs only if the motive power is greater than the resistance. Second, it is assumed that the velocity has some kind of functional dependence on the ratio of the motive power to the resistance. Bradwardine shows that if this function is supposed to be one of simple proportionality, the first assumption cannot stand. For, if a certain velocity is produced by some ratio of F to R, say, a ratio of 3/1, then if we divide that velocity by a number equal to this given ratio (or by 3), it will follow on Aristotle's law that this second velocity is produced by a ratio of equality between F and R. But it was postulated that when motive power and resistance are equal, there is no velocity at all, but a state of equilibrium.

In order to eliminate the contradiction involved in the formula of simple arithmetic proportionality, Bradwardine reformulates the law as an exponential function in which the integral series of velocities is correlated with an exponential series of values of the ratio F/R. Thus, if a given velocity arises from a certain ratio F/R, such as is greater than the ratio 1/1, twice that velocity will be produced by a ratio $(F/R)^2$, three times the velocity by a ratio $(F/R)^3$, one half the velocity by a ratio $\sqrt{F/R}$, and so on. Bradwardine's law, therefore, would be expressed in modern notation as a logarithmic function of this form: $V = \log_k(F/R)$, where the log base k is a constant such as is equal to F/R when the velocity $V = 1$. Since the logarithm of 1/1 is zero, the first postulate is satisfied, that where force and resistance are equal, velocity is zero.

This law of motion is erroneous under any recognized modern interpretations that can be given to the factors of motive power and resistance. Bradwardine himself makes no attempt to give empirical meanings to these factors, his entire concern being that of finding a mathematical function which satisfies the two basic postulates accepted from Aristotle, and which is internally consistent and wholly general. But, in carrying out this task, Bradwardine introduced two new ideas of great historical significance. First, he introduced an exponential function into the statement of a law of physics, for the first time in history; and, in view of the fact that nearly all our modern mechanical laws, in their algebraic formulations, involve exponential functions, this innovation must be considered important for later developments. Second, in his discussion of his law and of objections to it, Bradwardine makes it clear that his law is stated for *velocities* in the differential or "instantaneous" sense, and that it is not intended to express the proportion of total distances traversed in the whole time of the motions compared. Bradwardine calls the differential velocity the "quality" of the motion, distinguishing it from the integral sense which depends on the length of the time of the motion, and which he calls the "quantity" of the motion. He makes this distinction in discussing the objection that two bodies might traverse equal distances in an equal time, even though they are not moved at the same velocity during any finite part of the time. Such would be the case, for example, if one body were moving at constant velocity while the other was uniformly accelerated from rest to a terminal velocity twice as great.

It was among Bradwardine's pupils and younger colleagues at Merton College that these new ideas received their fruitful development. Between the years 1330 and 1340, three of these Mertonians, John Dumbleton, William Hentisberus, and Richard Swineshead, wrote treatises in which the concept of instantaneous velocity was given precise definition and applied in an exact and substantially correct analysis of uniformly accelerated movement. We may quote from Hentisberus' treatise *On Local Motion* to exhibit the accurate way in which these ideas were developed.[3] After stating that the movement of a body as a whole is that of its most rapidly moving point, Hentisberus writes as follows:

> Of local motions, that motion is uniform in which an equal distance is continuously traversed with equal velocity in equal parts of the time. . . . But in non-uniform local motion, the velocity at any assigned instant is determined by the path which *would* be described by the most rapidly moving point if, in a period of time, it were moved uniformly at the same velocity with which it is moving in that assigned instant, whatever instant be assigned. . . .
>
> For it is not required, in order that any two points . . . be moved at equal velocity, that they should traverse equal spaces in an equal time; but it is possible that they traverse unequal spaces in whatever proportion you please. For suppose that point A is moved continuously and uniformly at C degrees of velocity, for an hour, and that it traverses a distance of two feet. And suppose that point B begins its motion from rest, and in the first half of that hour accelerates its velocity to C degrees, and in the second half hour decelerates from this velocity to rest. It is then found that at the middle instant of that whole hour, point B will be moving at C degrees of velocity, and will fully equal the velocity of the point A. And yet, at the middle instant of that hour, B will not have traversed as long a line as A. . . [Fig. 1].

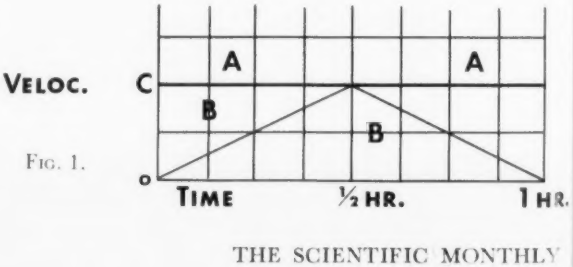

FIG. 1.

From this it clearly follows that such a non-uniform or instantaneous velocity is not determined by the distance traversed, but by the distance which would be traversed by such a point if it were moved uniformly over such or such a period of time at that degree of velocity with which it is moved at that assigned instant.

After defining a uniformly accelerated motion as one in which an equal *increment* of velocity is acquired in each equal part of the time, Hentisberus raises this question: If one body is uniformly accelerated from rest to a certain terminal velocity, in a certain time, at what velocity would another body have to move, if it were moved at constant velocity for that same length of time, in order to traverse the same distance traversed by the accelerated body? Hentisberus' answer is the one that we give now: "The moving body which is accelerated uniformly during some assigned period of time, will traverse a distance exactly equal to what it would traverse in an equal period of time if it were moved uniformly at its mean degree of velocity."

Where the acceleration is from rest to some assigned terminal velocity, Hentisberus continues, the mean degree will be one half of that terminal velocity. This yields the equation $s = \frac{1}{2}v \cdot t$, where s represents distance, v the terminal velocity, and t the length of the time. Since the terminal velocity v is obtained by multiplying the rate of acceleration (symbolized by a) by the time-length t, we may substitute $a \cdot t$ for v, in Hentisberus' equation, and obtain the familiar formulation of the kinematic law of uniformly accelerated motion: $s = \frac{1}{2}a \cdot t^2$. Hentisberus makes his meaning concretely evident by this corollary: "When the acceleration takes place uniformly, from rest, the distance traversed in the first half of the time will be exactly one third of the distance traversed in the second half of the time."

Extending this relationship to subsequent equal divisions of the time, we obtain Galileo's formulation of the law of uniformly accelerated motion, according to which the spaces traversed in equal successive parts of the time will be related as the series of odd numbers. The precision and clarity of Hentisberus' discussion leave no room for doubt of the fact that the kinematic law of uniformly accelerated motion, which was one of the cornerstones of Galileo's mechanics, was clearly understood and clearly stated in the early fourteenth century. To prove it, in what would be considered an adequate manner by present-day standards, requires the powerful tool of the calculus, not available prior to Newton's time. But this proof was approached, with clear consciousness of the infinitesimal problem involved, by these fourteenth-century "calculators" of Merton College. Their proofs are highly complex, but essentially sound. A simpler form of proof, by use of graphic representation through geometrical figures, was developed later in the fourteenth century by Nicole Oresme;[4] and it was this geometrical demonstration that Galileo employed in 1610 or later.

Oresme represents the time in which the motion occurs by a horizontal line, and he represents the velocity of the motion, at any given instant, by a vertical line erected on the horizontal (Fig. 2). If

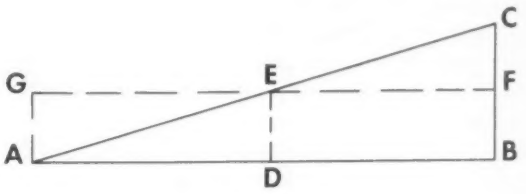

FIG. 2.

the motion is at constant velocity, it will be represented by a rectangle; if it is uniformly accelerated from rest, it will be represented by a right triangle. Oresme then supposes that the distance traversed in the whole time is represented by the area of the figure, since this area is an integral, or sum, of the infinitely small displacements corresponding to the instantaneous velocities at each instant of the time. To prove Hentisberus' equation, $s = \frac{1}{2}v \cdot t$, Oresme needs only to show that the area of the triangle ABC (representing the distance traversed in the accelerated motion), is equal to the area of the rectangle $ABFG$ (which represents the corresponding uniform motion). But it is easily proved, by elementary geometry, that the triangle AGE is equal to the triangle EFC, and that ED, bisecting the base AB at its mid-point D, is equal to FB and consequently equal to $\frac{1}{2}BC$. The step-by-step development of Oresme's proof, as also of the algebraic proofs offered by the Oxford calculators, indicates that these men were keenly aware of the implications of their methods of integrating "instantaneous velocities," as involving fundamental problems of continuity and convergence to limiting values.

III

What is perhaps most striking about the work of the Oxford calculators is their complete indifference to the empirical interpretations of which their highly developed kinematic analyses were susceptible. Their attitude was wholly abstract, their interest in motion being that of mathematicians to whom the constantly changing functional dependence of space traversed on time elapsed presented an interesting problem for abstract analysis. It was only at Paris, during the middle years of the

fourteenth century, that the kinematic analysis of uniformly accelerated movement, with its concepts of instantaneous velocity and of uniform acceleration, received a dynamical and empirical interpretation. This second fundamental contribution to the development of modern mechanics was largely made by Jean Buridan, who taught on the Parisian Faculty of Arts from 1328 to 1358.

Buridan's starting point was a criticism of Aristotle's explanation of the movement of projectiles. Aristotle had assumed that, if a body is moving in a direction contrary to that of its "natural" motion, it must necessarily have some body in contact with it which is pushing or pulling it in this direction. Yet if a stone is thrown into the air it continues to move upward after the thrower is no longer in contact with it. Rather than abandon his general principle, Aristotle tried to explain this by the theory that the air, initially compressed by the violent movement of throwing, follows after the stone and keeps pushing it upward for a time. This feeble theory was a cause of much discussion and criticism during the fifty years prior to Buridan's time, and various alternative solutions were suggested. Buridan, after refuting Aristotle's theory by a number of empirical arguments, offers his own solution in these words:

> The mover, in setting the projectile in motion, gives to it a certain *impetus*, or a certain energy (*vis*), by which that projectile keeps moving in the direction in which the mover set it in motion. . . . The more rapidly the mover moved it, the greater the *impetus* which was given to it; and it is by that *impetus* that the stone is moved after the thrower ceases to move it. But by the resistance of the air, and by the gravity of the stone (which tends in a direction contrary to that in which the stone tends in virtue of its *impetus*), this *impetus* is continuously diminished, so that the movement of the stone becomes continuously slower; and the *impetus* is finally decreased to the point where the gravity of the stone exceeds it and causes the stone to fall downward toward its natural place. . . .
>
> If then it is asked why I throw a stone further than a feather, and an iron weight (of a size proportionate to my hand) further than a wooden one of the same size, I say that the cause of this fact is that the reception of all natural forms and conditions in matter, is determined according to the matter. Hence, the greater the *quantity of matter*, the greater the degree of *impetus* that the body can receive. Now in the dense and the heavy, other things being equal, there is more primary matter than in the rare and the light; consequently the dense and the heavy receive a greater *impetus*, just as iron receives more heat than an equal volume of water or wood. A feather, however, receives *impetus* in such a small degree that this *impetus* is quickly overcome by the resistant air.[5]

The concept of *impetus*, as defined and used by Jean Buridan, represents a new factor in the analysis of motion, not involved in the Aristotelian dynamics. And the concepts in terms of which it is defined likewise are new—namely, that of "quantity of matter," and that of velocity (here taken in its "qualitative," or differential, sense). Although the "quantity of matter" of a body is said to be *proportional* to its weight or gravity, it is distinguished from weight, being taken as a scalar quantity and not a vector quantity. Thus it functions, in the definition of impetus, exactly as *mass* does in the definition of *momentum*; and impetus is here defined by the product of mass and velocity, so that it is equivalent to what we call momentum in Newtonian mechanics.

More significant is Buridan's further statement, that impetus is an "enduring reality," a condition that remains constant except insofar as gravity or other forces operate to increase or diminish it. Buridan states this very explicity, in these words: "This impetus would endure for an infinite time, if it were not diminished and corrupted by an opposed resistance or by something tending to an opposed motion."[6]

These statements of Buridan obviously suggest Newton's first law of motion, according to which a body continues to move with whatever velocity it has, except insofar as it is acted upon by a force. Although Buridan may not have realized the immense import of this "principle of inertia" for the science of mechanics as a whole, he seems to have recognized it, and to have used it with conscious intent, in his explanation of projectile motions. But he went further than this, by introducing the concept of impetus into the analysis of the uniformly accelerated movement of freely falling bodies, with the result that the force of gravity is defined as that which continuously increases the impetus of the body on which it acts.

> It must be imagined that a heavy body acquires from its primary mover, namely from its gravity, not merely motion, but also, with that motion, a certain *impetus* such as is able to move that body along with the natural constant gravity. And because the *impetus* is acquired commensurately with motion, it follows that the faster the motion, the greater and stronger is the *impetus*. Thus the heavy body is initially moved only by its natural gravity, and therefore slowly; but it is then moved by that same gravity, as well as by the *impetus* already acquired, and thus it is moved faster . . . and so it is continuously accelerated always, to the end.[7]

Although Buridan's manner of expressing this dynamical analysis of gravitational motion is somewhat crude, the fundamental principle is nevertheless recognized and stated, that the effect of gravity (just as of other forces such as air resistance) is to *change* the momentum of a body continuously with the time. Thus the modern conception of *force*, as measured by the rate of acceleration of a body and by its mass, or by the rate at which it changes the momentum of a body,

is applied by Buridan to the analysis of freely falling bodies and to the definition of gravity. Just as Newton's second law of motion follows from his first law, so Buridan's conception of gravity as a force whose effect is to change the momentum of the body on which it acts follows as a consequence of his definition of impetus as an "enduring condition" measured by velocity and "quantity of matter." It seems likely that Buridan, who was familiar with the kinematical analyses emanating from the Oxford school, was guided in this new dynamical analysis of the movement of projectiles and of freely falling bodies by the mathematical patterns established in the abstract analysis of uniformly accelerated motion. Buridan did not, however, bring his own dynamical analysis of gravitational motion into explicit association with the kinematic law relating distance traversed to time elapsed. This was done by Domenicus Soto, in a work published at Salamanca in 1572.[8] But Soto's entire discussion of motion, in both its kinematic and dynamic aspects, is wholly dependent on the works of the Oxford calculators and of the Parisian school of Jean Buridan.

In the foregoing sketch we have picked out the two developments of fourteenth-century mechanics that stand at the beginning of the great shift from Aristotelian physics to the modern Galilean-Newtonian mechanics. These fourteenth-century contributions are sufficient to show that modern physics, and the two basic laws of motion represented by $s = \frac{1}{2}a \cdot t^2$ and by $F = m \cdot a$, grew from earlier beginnings some three hundred years before Galileo "founded" modern physics. To what extent this fourteenth-century tradition influenced Galileo and other seventeenth-century physicists in their work is a question that cannot be answered until a great deal more historical evidence has been uncovered and examined. But it may at least be said that the background of ideas within which the seventeenth-century physicists worked stemmed in large measure from the later Middle Ages and undoubtedly influenced the direction in which modern physics developed.

The deficiencies of fourteenth-century mechanics were very great, and sufficient to prevent any full-fledged development of the fertile ideas and keen mathematical analyses which are to be credited to Buridan and to the Oxford calculators. The medieval interest in physics was dialectical and abstract, rather than experimental. No real effort was made to test or confirm the theories proposed, by observation and experiment; the formulas devised to express the relations of dynamic factors in motions were given no operational interpretations by means of procedures or units of measurement. Even the mathematical developments, which clearly foreshadow the functional and differential methods of modern mathematics, could scarcely be carried to any fruition until symbolic notations adequate to these methods had been developed. Perhaps the primary historical significance of the fourteenth-century effort to achieve a quantitative and functional analysis of motion is that it made evident the need for a new kind of mathematics, and by its crude attempts to carry out differentiations and integrations of velocities showed what form this new mathematics would have to take. This in itself was a magnificent achievement, even though it required more than three hundred years for the seeds planted in the fourteenth century to grow to maturity.

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The Fourteenth-Century Discovery of America by Antonio Zeno

WILLIAM HERBERT HOBBS

The author, who took his Ph.D. in geology at Johns Hopkins in 1888, is, in his eighty-seventh year, as enthusiastic and dynamic a worker as ever he was in the days when he was director of the University of Michigan Expeditions to Greenland. Professor emeritus of geology at Michigan since 1934, he continued as vice president of the International Glacier Commission until 1936 and in divers ways has maintained his interest in the world of geology and geography.

WAS there really a discovery of the Western world before that of Columbus? Historians, although considering it probable that the Viking Leif Eriksson made a landfall on the mainland of North America sometime in the tenth century, credit Columbus with the first definitely known discovery of the Western world. Yet there is the well-authenticated narrative account of extensive explorations over the North Atlantic in the 1390s by the Venetian brothers Nicolò and Antonio Zeno. Antonio, the younger, described in letters a voyage of many days sailing in a direction due west from Iceland to a very extensive New World, with the first landfall made on a mountainous island about the size of Iceland, which could only have been Newfoundland.

If Zeno had sailed, as he claimed, in a direction due west from Iceland, he must have been off the east Greenland coast after sailing less than four hundred miles, and his new world would have been, not North America, but Greenland. With a few exceptions, modern historians have discredited the Zeno brothers and have rather generally classed them with Dr. Cook.

At the time their account of their voyages was first published, in 1558, more than a century and a half after they had been made, their map and narrative accounts were accepted by the greatest geographers of the period; as, for example, by Ruscelli in 1564, by Mercator in 1569, and by Ortelius in 1574.

Unfortunately, the original Zeno map, which, with the letters, had been stored in the palace of the Zeno family in Venice, had been found there by a descendant, Nicolò Zeno, who in publishing the letters had superimposed upon the map a series of parallels of latitude with false values printed on them. The primitive sextant, the astrolabe, had since the time of the Zeno explorations been put to use to measure latitudes at sea, and mariners had begun to help fix their positions by its use. The false latitudes thus added to the Zeno map soon brought it into discredit, and modern historians, apparently unaware of this, have without just cause maligned these honest and quite competent discoverers.

Today it is possible to show that Antonio Zeno landed on both Newfoundland and Nova Scotia in the 1390s. How I have been able to prove this is not without some interest. Being asked by the American editor of *Imago Mundi* for an article on early Greenland maps, I was led to examine with some care the first maps on which Greenland had been represented. The earliest map on which that island had appeared in any semblance of its actual outline, and the first to show land in northern North America, had been made in the 1390s by Nicolò and Antonio Zeno.[1] This was after exploration of both the eastern and western coasts, but the map had not been published until 1558, a century and a half later.[2] The book containing the Zeno narratives and map is now very rare, and only three copies are known to exist in the United States.[3] A book by Lucas with facsimiles of the pages of the original, together with an English translation of the Italian text, is also now quite rare.[4]

The brothers Zeno were of a patrician family of

Venice, high in the councils of the state. Wealthy shipowners, both of them had from boyhood been much upon the seas. Their exploring careers were started from Iceland,[5] where both of them died without ever returning to their native land. The narratives of their explorations were contained in letters sent to Antonio or Carlo Zeno before either of these brothers had left Venice, and in the manuscript of a book by Antonio sent to Carlo. The book with letters and map were all discovered in the Zeno palace at Venice, more than a century later by Nicolò Zeno, the great-great-great-grandson of Antonio. As a boy, Nicolò had played with these precious documents and, boylike, he had torn the manuscript of the book to pieces. Grown to manhood, he realized the value of the papers, found the letters and map intact, and prepared them for publication, adding explanatory matter of his own as "narrator." The map he described as already "rotten." Most unfortunately, he superimposed upon the map a network of meridians and parallels with, for the map, impossible figures for latitude. The explorers had, of course, not taken latitudes and had never even mentioned them, the astrolabe having been brought into use to fix latitude a century after their time.

The Zeno map, photographed from the original Zeno book, is here reproduced as Figure 1, but without the superimposed grid of parallels and meridians. The original map without change is reproduced on page 15 of Volume VI (1950) of *Imago Mundi*. The Zeno map had, of course, no common scale, for distance traveled on the sea could only be guessed at. Islands had been given such size as was needed to display what was known —bays, capes, towns, etc. To judge whether actual exploration had been the basis for the map, the direction of coasts is the best criterion, for until the mariner's compass had come into use ship voyages had been mainly along coasts. The vessels were obliged to anchor at nightfall, and after the compass came into use this custom was continued so far as was practicable.

The Zenos appear to have been among the very earliest deep-sea explorers to steer their ships by compass. Their instrument they referred to by the Italian word *calamitá* ("lodestone"), the primitive form then coming into use in the Mediterranean and North Atlantic. The *calamitá* was a splinter of lodestone, or a needle of soft iron rubbed with lodestone, thrust through a reed or small raft of cork, and floated in a basin of water. The later form with a pivoted needle went by the Italian name of *bossola*. The compass needle was at the time supposed to point to the north, though its pointing, it was much later learned, was toward the earth's magnetic North Pole, which was first discovered by James Clark Ross in 1831 in longitude 96° W., more than a thousand nautical miles to the south of the geographic pole.

I have long been a student of Greenland, and its outline is photographed upon my memory. When I first examined the Zeno map, therefore, I became fully convinced that Greenland must have been actually skirted and surveyed with compass by these explorers. The fact that the long axis of the island appeared rotated clockwise through about half a right angle is a principal reason why so much discredit has been heaped upon the Zeni.

The reason for the large clockwise rotation of Greenland on the Zeno map is not far to seek. Until comparatively recent times, the local variation of the compass needle from the true north was not accurately known, and in moderate latitudes it is in some areas, and especially in the United States, so small as not very greatly to distort the maps. Within the arctic region, however, compass variation is excessive, and rather generally equal to half a right angle or more.[6] For the Greenland region, some of the compass variations measured in degrees of arc have been entered on the map of Figure 2. It is a simple matter to introduce these corrections on the Zeno map. By doing this, their magnetic map of Greenland (Fig. 1) becomes transformed into the map of Figure 3, which corresponds closely with the modern map of Figure 2.

Had the Zeni produced a correct present-day map of Greenland, they would thereby have shown themselves to be early "Dr. Cooks." That they produced an uncorrected but true magnetic map of the island is proof positive that they were honest and very competent explorers.

It is not so easy to explain the chorus of denunciation of the Zeno brothers by modern geographers and later critics generally. Some polar authorities, knowing the arctic, and themselves distinguished arctic explorers, have each in turn declared the Zeno narrative to be fiction. With some experience of the North, I have read most carefully the full Zeno narrative and can find no statement in it which cannot now be proved to be either true or at least probable. Their account, I believe, will stand comparison with the cautiously worded narratives of our best modern explorers.

Probably that part of the Zeno narrative which has been most criticized as quite fantastic is Nicolò's account of what he found when he had landed on the east Greenland coast, almost certainly the neighborhood of Gael Hamke Bay, the later Hud-

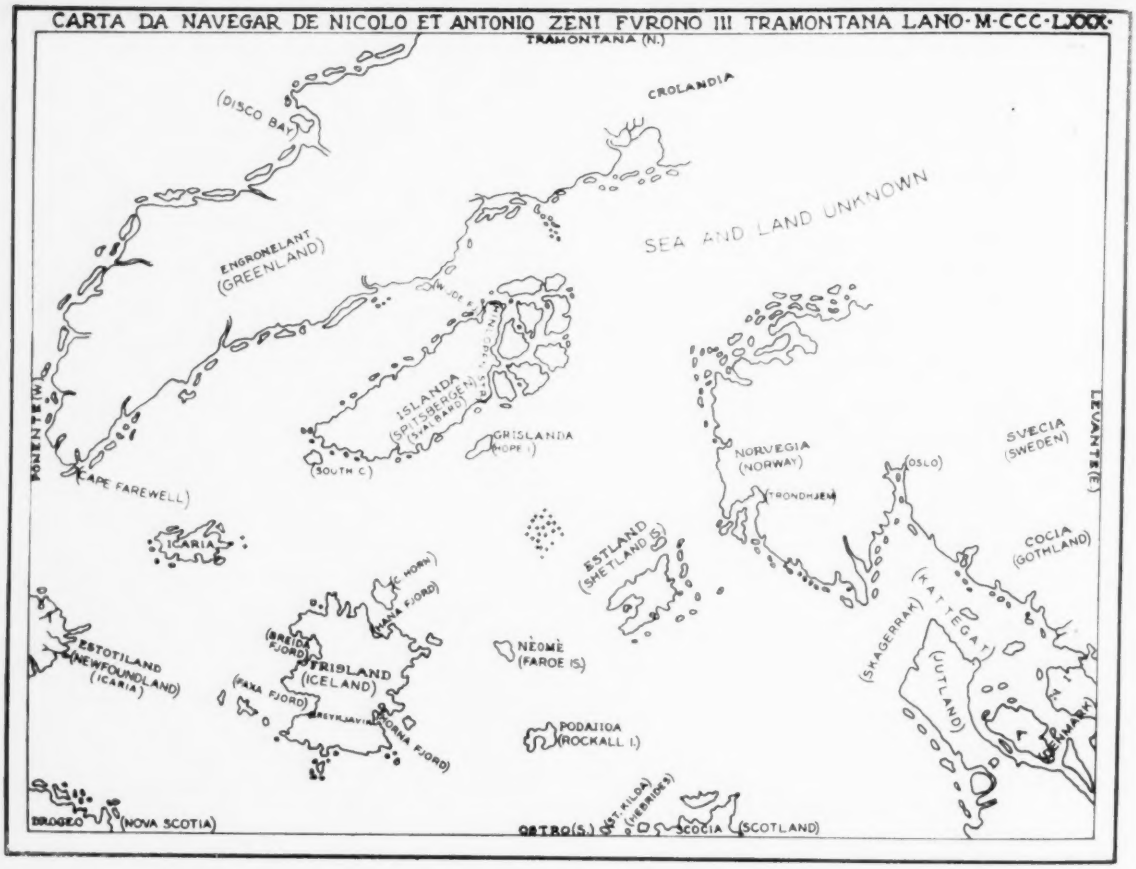


FIG. 1. Zeno map with the later superimposed network of meridians and parallels, also latitude figures, deleted. In parentheses, modern place names have been added so far as this seemed advisable.

son Land, and Clavering Island (Fig. 2). Nicolò's narrative at first sounded most improbable, for modern explorers had found no inhabitants there, nor evidence of any earlier ones. They found no active volcano, nor any hot spring. Yet during the last half-century remains of all these have been discovered. It will be best to print Nicolò's narrative here, with interjected comments on the recent discoveries.

To cite (p. 11 of the Lucas translation and following):

> There [east Greenland coast] he [Nicolò Zeno] found a Monastery of the order of Preaching Friars, and a Church dedicated to St. Thomas near to a mountain which cast out fire like Vesuvius and Etna. [The only known volcano discovered in Greenland and one that was probably in eruption within the past five hundred years was found here by the Swedish explorer Nathorst in 1898.[7]] There is there a spring of hot water with which they warm the buildings in the Church of the Monastery, and the chambers of the Friars, the water in the kitchen being so boiling that, without any other fire, it serves all their needs; and bread, being put into copper cooking-pots without water, is cooked as in a well-heated oven. [These hot springs, always an evidence of recent volcanic activity, were first reported by Nathorst at this locality, the only ones known in Greenland. Hot springs in the course of time change their volumes and temperatures, usually during local earthquakes. The present temperature of the Hamke Bay springs is 140° F.[8] Such natural hot springs associated with active volcanoes have been used for heating houses in Iceland since the thirteenth century and must have been seen by the monastery friars while en route from Norway to Greenland.] And there are little gardens covered in the winter, which, being watered with this water, are preserved from the snow and the cold, which in these parts, on account of their situation, being so very close under the Pole, are exceedingly severe. From these gardens are produced flowers and fruits of various kinds, just as they are in temperate climates in their seasons, so that the rough and wild peoples of these countries [Eskimos], seeing these supernatural effects, consider the Friars as Gods, and bring them fowls, flesh, and other things, and hold them all as Lords in the greatest reverence and respect. . . . [Successful small winter gardens heated artificially are now operated throughout the year on the arctic coast of Siberia.[9]]
>
> Most of the roofs are made in the following manner: the wall being carried to the proper height, they then incline it inwards little by little as they go on, so that in the middle it forms a rainproof arch; but they have not much apprehension of rain in those parts, because the Pole, being, as has been said, very cold, the first-fallen

snow melts no more until nine months of the year have passed, for so long does the winter last. [A very accurate characterization. These rock houses were modeled on the Eskimo snow igloos.]

The houses of these people surround the mountain [the volcano], and all are circular in shape and twenty-five feet in diameter . . . and the earth is so warm below that they do not feel any cold within. Hither, in the summer, come many boats from the neighbouring islands and from the cape upon Norway, and from Treadon [Trondhjem?], and bring to the Friars all the things which they can desire, and they trade [exchange] with these for fish, which they dry in the open air and in the cold, and for skins of different sorts of animals. Thus they acquire wood for burning, and timber, excellently worked, for building, and grain, and cloth for clothing; for, in exchange for the two things mentioned, nearly all the neighbouring people are desirous of selling their merchandise. . . . [A quarter of a century ago almost no one would have accepted the view that any people, either Eskimos or Europeans, had had settlements on the east Greenland coast. In the early 1930s, however, the ruined houses, graves, skeletons, implements, etc., of what must have been a settlement of hundreds of Eskimos were discovered in this very area around Gael Hamke Bay.[10] It would have been even harder to convince historians of Greenland that a monastery of Catholic friars had been located there. Yet the evidence is now available. The Viking settlements in south Greenland, Vestri Byggd (Godthaab) and Eystri Byggd (Julianahaab) had been abandoned, it is believed, before the end of the fourteenth century, but in 1448 Pope Nicolas V wrote that the Christians in Greenland had thirty years before (1418) been attacked by barbarians (roving pirates), with many killed and others taken captive. This must therefore have been in the east Greenland settlement and have referred to an attack from the sea. Vatican records show further that a Catholic bishop in Greenland was drawing a salary as late as 1537.]

There come together in this Monastery Friars from Norway, Sweden and other countries, but the greater part are from Islanda [Spitsbergen]; and there are always in this port many ships which cannot get away because the sea is frozen, awaiting the spring thaw. [Modern explorers have always this experience.]

The boats of the fisherman they make like the shuttles which the weavers use to make cloth [an excellent description of Greenland kayaks at a time when each home had its hand loom]. Taking the skins of fishes [seals], they fit them over the bones of the same fish, of which they make a frame and sew them together, and lay them over many times double [a good description of the Eskimo kayak]. They turn these boats out so strong and sound, that it is certainly a miraculous thing to observe how, during tempests, they fasten themselves inside [by tying their jackets over and around the raised washboards of the kayak cuddies], and allow them to be carried over the sea by the waves and the winds without any fear of being wrecked or drowned [the Eskimos do this today in their kayaks]; . . . They use, for the most part, the Latin language, especially the superiors and the principal men of the Monastery.

Having now, it is hoped, re-established the reliability of the Zeno letters, we turn to the account of Antonio Zeno's expedition from Iceland to the westward (compass direction as corrected, S. 55° W.) and his landing on the coast of America, clearly in Newfoundland (Estotilanda, or Icaria) and Nova Scotia (Drogeo) (Figs. 1, 2). A fleet of fishing boats from Iceland, driven by a great storm, had sixteen years before been wrecked on Estotilinda far to the west, and after sixteen years spent there, one of these fishermen had, by building a small ship and with some of his fellow-fishermen as sailors, been able to get back to Iceland. Estotilanda he described as

very rich and abundant in all good things of this world; that it is rather smaller than Iceland [Newfoundland, 42,200 square miles; Iceland, 40,450], but more fertile, having in the middle a very high mountain [2,640 ft.], from which spring four rivers which water it [four great fjords with rivers flowing into them]. They get, by mining, metals of all sorts, and above all, they have abundance of gold. [This was probably pyrites, or "fool's gold," which is abundant there.] Their trade is with *Engroueland* [Greenland] whence they receive furs, and sulphur and pitch. [Here the Lucas translation is at fault. The Italian original is *di dove traggono*, "to where they take." Greenland has only dwarf willows, alders, and birches, but the coniferous forests of Newfoundland supply pitch which is needed in Greenland to caulk the kayaks and umiaks.] And, towards the south he says, there is a great country very rich in gold and populous. They sow grain and make beer, which is a kind of beverage which the Northern people use as we do wine. [Antonio is here writing as an Italian.] They have woods of immense extent. . . . They make small ships [birch canoes] and navigate them, but they have not the lodestone, nor can they indicate the north by the compass. On this account these fishermen were held in great esteem, so that the king dispatched them, with twelve small ships, towards the south to the country which they called *Drogeo* [Nova Scotia, and farther south, to the eastern United States]. . . . He says that it is a very large country, and like a new world; but the people [American Indians] are ignorant and devoid of all good qualities, for they all go naked, and suffer cruelly from the cold; nor have they learnt how to cover themselves with the skins of the beasts which they take in hunting. They have no metal of any sort. They live by hunting, and carry lances of wood sharpened at the point, and bows, the strings of which are made from the skins of animals. . . . But the farther one goes towards the Southwest the greater civilization one finds, because there the temperature is more temperate, so that there are cities, and temples of idols, wherein they sacrifice men, whom they afterwards eat.

Because of the quite general inaccessibility of the Zeno book, it seems best to here publish *in extenso* Antonio's narrative of his own voyage as navigator of an Icelandic fleet of vessels under Prince Zichmni from Iceland to America. It is as follows:

Our great preparations to go into Estotilanda [Newfoundland] were commenced under an evil omen; for, three days exactly before our departure, the fisherman, who was to have been our guide, died. Notwithstanding this, our Chief, Prince Zichmni, would not abandon the intended voyage, and took with him as guides, instead of the dead fisherman, some of the sailors who had re-

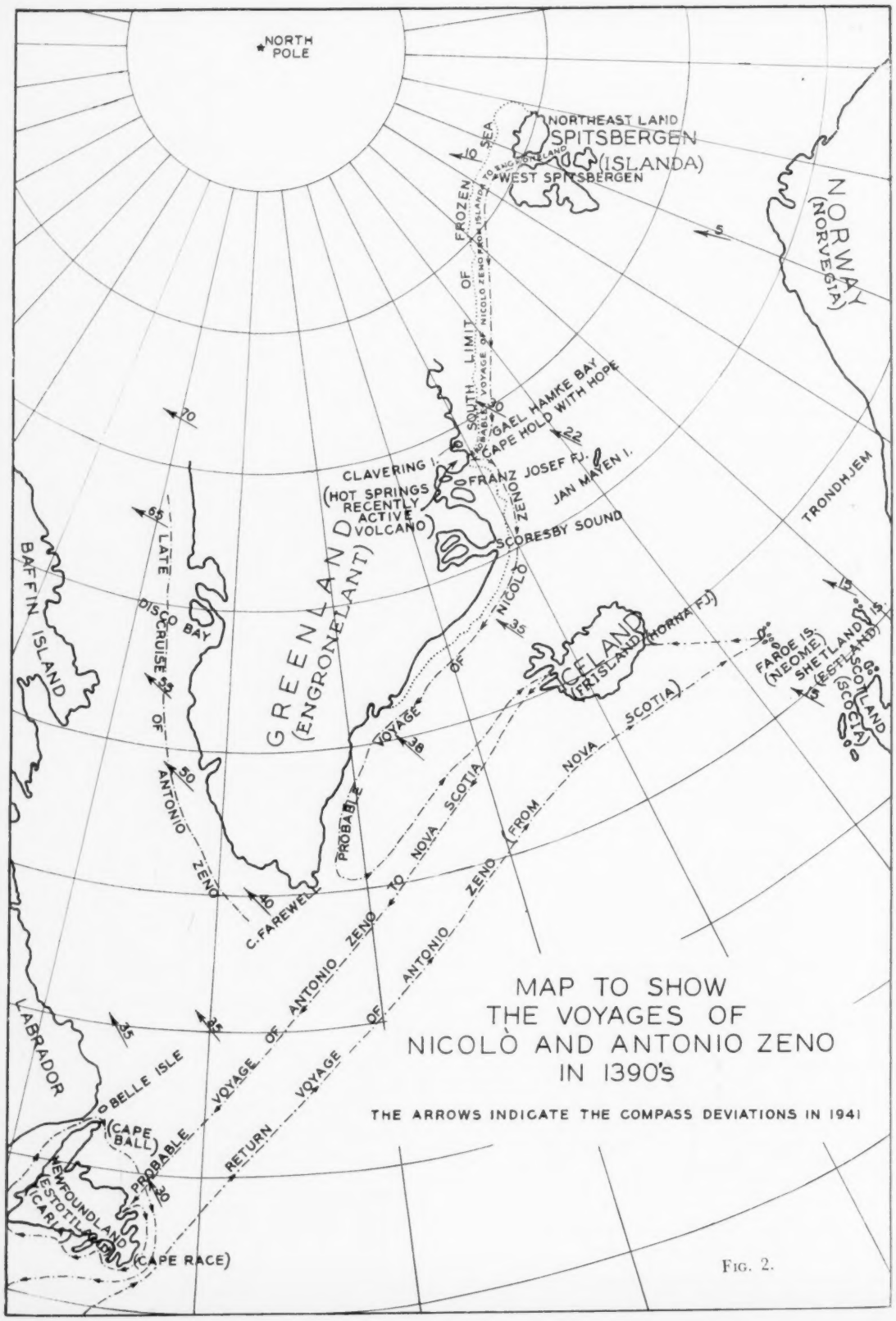

NORTH POLE
NORTHEAST LAND
SPITSBERGEN
(ISLANDA)
WEST SPITSBERGEN
NORWAY
(NORVEGIA)
FROZEN SEA
SOUTH LIMIT OF PROBABLE VOYAGE OF NICOLO ZENO FROM ISLAND TO KING CHRISTIAN'S LAND
GAEL HAMKE BAY
CAPE HOLD WITH HOPE
FRANZ JOSEF FJ.
JAN MAYEN I.
CLAVERING I.
(HOT SPRINGS RECENTLY ACTIVE VOLCANO)
ZENO
SCORESBY SOUND
TRONDHJEM
BAFFIN ISLAND
LATE DISCOVERIES OF CO BAY
GREENLAND
(ENGRONELANT)
NICOLO
ICELAND
(FRISLAND)
HORNA FJ.
FAROE IS.
(NEOME)
SHETLAND IS.
(ESTLAND)
SCOTLAND
(SCOCIA)
VOYAGE OF ANTONIO ZENO TO NOVA SCOTIA
PROBABLE
FROM NOVA SCOTIA
ANTONIO ZENO
C. FAREWELL
LABRADOR
BELLE ISLE
(CAPE BALL)
NEWFOUNDLAND
(ESTOTILAND)
(CARIA)
(CAPE RACE)
VOYAGE OF ANTONIO ZENO
PROBABLE RETURN VOYAGE OF ANTONIO ZENO
MAP TO SHOW
THE VOYAGES OF
NICOLÒ AND ANTONIO ZENO
IN 1390's
THE ARROWS INDICATE THE COMPASS DEVIATIONS IN 1941

FIG. 2.

turned from that Island with the latter. And so we steered our course towards the West [compass direction corrected S. 55° W., Fig. 1], and discovered some islands subject to Frislanda [Iceland]; and, passing certain rocks, we stopped at Ledovo [Fig. 1], where we remained seven days for the sake of the repose, and to furnish the fleet with some necessary things. Departing from thence, . . . because the wind made for us, we passed onward, without the least thing to hinder us, and went far out into the deepest ocean. Not long after, a storm assailed us, so fierce that, for eight days at a stretch, it kept us at work, and cast us about so that we knew not where we might be, and we lost a large proportion of the ships. At last, the weather having become calm, we got together the ships which had been separated from the others, and, sailing with a good wind, we discovered land in the West. Keeping our course directly for it, we arrived in a quiet and secure port [probably on Newfoundland's northeast coast (Fig. 2)], and we saw people, almost infinite, in number, armed and ready to strike, running towards the shore to defend the Island. Thereupon, Zichmni ordered his people to make signs of peace, and the Islanders sent to us ten men, who could speak ten languages, but we could not understand any of them, except one who was from Islanda [Spitsbergen]. This man, being conducted into the presence of our Prince, and asked by him how they called the Island, and what people inhabited it, and who ruled over it, replied, that the Island was called Icaria, and that all the Kings who had ruled over it were called Icarus, after its first King, who, as they said, was the son of Daedalus, King of Scotland [the King was likely enough from Europe and may have used the Icarus myth to cover his origin], who, having made himself master of the Island, left his son there as King, and left also those laws which the Islanders still used; and that, after these things were done, purposing to sail further on, he was drowned in a great storm; that, on account of his death in this manner, they still called that sea Icarian, and the King of the Island Icarus. Also that, because they were satisfied with that state which God had given them, they did not wish to change their customs in any particular, nor would they receive any foreigner; that they therefore prayed our Prince that he would not seek to violate those laws which they had preserved in happy memory of their King, and had observed down to that time; adding that he would not be able to do it without his own certain destruction, they being all prepared to abandon life, rather than to give up, on any account, the use of those laws. Nevertheless, in order that it might not appear that they altogether refused intercourse with other men, they said, in conclusion, that they were willing to receive one of us, and to give him a high position amongst them, and to do so solely in order to learn my [*sic*] language and to have an account of our customs, just as they had already received those other ten men who had come to the Island from ten other different countries. To these things our Prince made no other reply than to make enquiry as to where there was a good harbour. Then he feigned to depart, and, making a circuit of the Island, in full sail, put into a port pointed out to him on the Eastern side [Cape Race]. There the sailors disembarked, to obtain wood and water, with as much despatch as possible, as they doubted whether they might not be attacked by the Islanders; nor was their fear vain, for those who dwelt near by, making signs to the others with fire and smoke, quickly armed themselves, and, the others joining them, they came down to the shore, armed with weapons and arrows, in such numbers against our people that many were left killed and wounded; nor did it avail us that we made signs of peace to them, for, as if they were fighting for their all, they grew more and more exasperated. Therefore, we were forced to set sail, and to go along in a great circle round the Island, being always accompanied, along the mountains and shores, by an infinite number of armed men. [There is no other large mountainous island on the east coast of North America.] Then, doubling the Cape at the North of the Island, we found very great shoals [such extensive shoals are off the northern coast of Newfoundland], amongst which, for ten days continuously, we were in much danger of losing the fleet, but luckily for us, the weather was very fine all the while. Passing thence as far as the Cape on the East of the island [Cape Race], we saw the Islanders, always keeping pace with us on the summits of the mountains and along the shore, with cries and arrow-shots from afar, showing towards us more and more the same inimical mind. We therefore determined to stop in some safe port, and to see if we could not speak once more to the Icelander; but we did not succeed in this design, for the people, little better than beasts in this respect, remained continually in arms, with the deliberate intention of resisting us if we should attempt to land. Wherefore Zichmni, seeing that he could not do anything, and that, if he should remain obstinate in his purpose, victuals would soon be wanting in the fleet, set sail with a fair wind and sailed six days to the Westward [southwestward]; but, the wind changing to the Southwest [south], and the sea therefore becoming rough, the fleet ran before the wind for four days. At last land was dis-

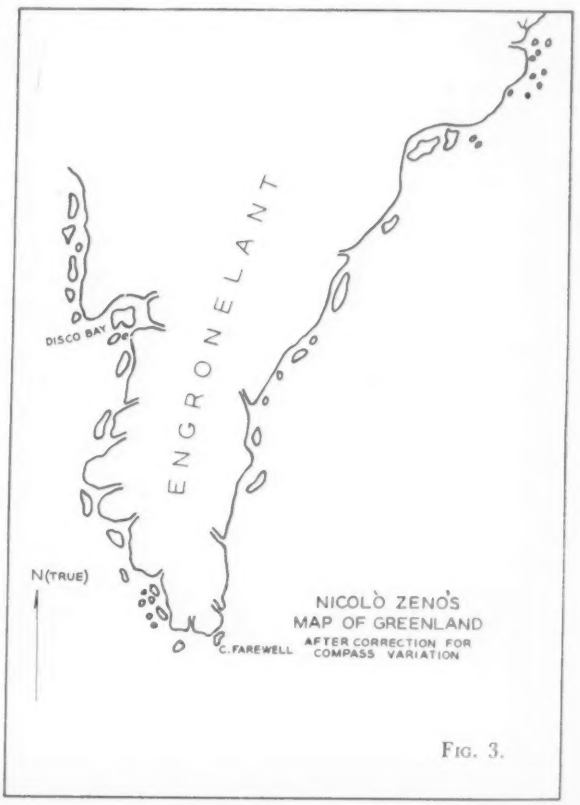


FIG. 3.

covered, but we greatly feared to approach it, on account of the swelling seas, and because the land observed was unknown to us. Nevertheless, by God's aid, the wind dropped and it became calm. Then some men from the fleet went to the land in rowing boats, and not long after returned and reported, to our very great delight, that they had found a very good country and a still better harbour. At which news, having hauled up our ships and small vessels, we went on shore, and, having entered a good harbour [from what follows, this was very likely Tor or Chedabucto Bay (Fig. 4)], we saw afar off a great mountain [*monte*, "hill", Nova Scotia has a low relief, but with one high hill in Antigonish County, which alone could be seen from afar] which cast forth smoke; this gave us hope that inhabitants would be found in the Island, nor, for all that it was so far off, did Zichmni delay sending a hundred good soldiers to reconnoitre the country and to report what kind of people inhabited it. In the meanwhile, the fleet was supplied with water and wood, and many fishes and sea-fowl were caught; they also found there so many birds' eggs that the half-famished men were able to eat their fill. [There are extensive fishing banks and rookeries of birds on the coast.]

While we remained here, the month of June [must have been later] came in, during which season the air in the island was more temperate and mild than can be expressed. In spite of this, not seeing anyone there, we began to suspect that so beautiful a place was, nevertheless, uninhabited, and we gave to the port and to the point of land which ran out into the sea the names of Trin and Capo di Trin. The hundred soldiers who had gone away returned, after eight days, and reported that they had been over the island [they had found a sea on the further shore; hence, they thought it an island] and to the mountain; that the smoke proceeded from it because, as they had proved, at the bottom of it was a great fire; that there was a spring from which was produced a certain matter, like pitch, which ran into the sea [this could only be asphaltum, which very rare substance is found in northwest Nova Scotia, now the Asphalt District of Stellarton[11]]; that many people inhabited the neighbouring parts, half savage, and sheltering themselves in caves[12] [Fig. 4]; that these were of small stature [Micmacs, the timid cave-dwelling aborigines of northwest Nova Scotia are small of stature and very timid], for, directly they saw the soldiers, they fled into their caves; and that there was a large river there [the estuary of a river twenty-five miles in length which flows past Stellarton and empties into Pictou Harbor], and a good and safe harbour [Chance Bay and Pictou Harbour]. Zichmni, being informed of these things, and seeing that the place had a healthy and pure climate, and very good soil, and rivers, and so many peculiar advantages, began to think of making his dwelling there, and of building a city. But his people, who had already endured a voyage so full of hardships, began to rebel, and to say that they wished to return home, because, as the winter was near, if they let it come in, they would not be able afterwards to get away until the following summer; so he retained only the rowing boats, with those men who were willing to remain there, sending back all the others in the remaining ships; and he desired, against my will, that I should be the Captain. I departed, therefore, because I could not do otherwise, and sailed towards the East [northeast] for twenty days continuously without ever seeing land; then, turning towards the Southeast [east], after five more days I sighted land, and found that I had reached the Island Neome [Faroe Island]. Knowing this country, I perceived that I had passed Islanda.[13] Wherefore, having procured fresh provisions from the Islanders, who were under the dominion of Zichmni, I sailed in three days, with a fair wind, to Frislanda, where the people, who believed that they had lost their Prince, because of the long time that we had spent upon the voyage, received us with signs of the greatest joy.

FIG. 4. Map of northeastern Nova Scotia to illustrate the landing there of Antonio Zeno.

(*By the Compiler*)

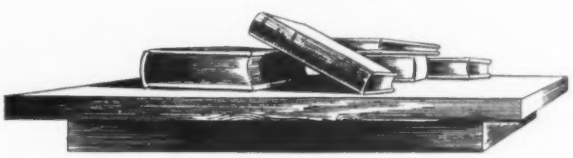
After this letter I find nothing further, except what I judge from conjecture. I gather, from a clause in another letter, which I give below, that Zichmni built a town in the port of the island newly discovered by him [sea on further side; hence, "island"]; also, that he [Antonio] did his best to explore the whole country, together with the rivers in various parts of Engroueland [Greenland], because I see these described in detail in the map, but the description is lost. The clause in the letter is as follows:

As to those things which you seek to know from me concerning the customs of the men, the animals, and the neighbouring countries, I have written about all these in a separate book, which, please God, I shall bring home with me. In it I have described the countries, the monstrous fishes [walrus and seals], the customs and laws of Frislanda, of Islanda, of Estlanda [Shetland], of the Kingdom of Norway, of Estotilanda, of Drogeo, and, lastly, the life of Nicolò the Knight, our brother, with the discoveries made by him, and matters relating to Grolanda [Greenland]. I have also written the life and exploits of Zichmni, a Prince certainly as worthy of immortal remembrance as any other who has ever lived in this world, on account of his great valour and many good qualities. In this life may be read of his discoveries in Engrouiland [*sic*] [Greenland] on both sides, and of the city built by him. Wherefore, I will say no more to you in this letter, hoping soon to be with you, and to satisfy you concerning many other things *viva voce*. [He never returned, but the book arrived, and, as earlier described, was destroyed by Nicolò the narrator when he was a small boy.]

An earlier discoverer of America, sixteen years before Zeno, was the nameless Icelandic fisherman who reported there others of doubtless European origin. It is an interesting fact that the four earliest known discoverers of America—Antonio Zeno (Newfoundland and Nova Scotia, 1390s), Cristoforo Columbo (San Salvador, West Indies, 1492), Giovanni Caboto (Newfoundland, 1497), and Giovanni Verazzano (entire Atlantic coast from Florida to Cape Breton Island, 1524)—should all have been Italians, each of them sailing in the service of another nation, respectively, Iceland, Spain, England, and France.

Notes

1. The *Carta Marina* of Olaus Magnus was issued nineteen years earlier with the outline of South Greenland a little like that of the Zeno map, indicating that it might have been copied from memory. There was no other known exploration on which the Olaus map could have been based. Olaus had been in Venice for publication of his map when Nicolò the younger was preparing his ancestor's map for publication there. Nicolò was a member of the powerful Council of Ten of Venice and, like Olaus, highly placed in the Church, and it is inconceivable that a Catholic prelate like Olaus should not have known of the Zeno map.
2. *De I Commentaraii del Viaggio in Persia di M. Caterino Zeno il K. & della guerre fatti nell' Imperio Persiano, dal Tempo di Vffun-Cassano in quà Libro Dae. Et dello Scoprimente dell' Isola Frislanda, Eslanda, Engrouelande, Estotilanda & Icaria, fattosotto il Polo Artico, da due fratelli Zeni, M. Nicolò il K. e M. Antonio. Libro Uno, Con un disegno particulari di tutte le dette parte di Tramontana da lor Scoperte. Con Gratia e privilegio. In Venetia Per Francesco Marcolino. MDLVIII.*
3. In the Clements Library, Ann Arbor, in the library of the Surgeon General's Office, and in the Library of Congress.
4. Lucas, F. W. *The Annals of the Voyages of the Brothers Nicolò and Antonio Zeno in the North Atlantic about the End of the Fourteenth Century, and the Claim Founded Thereon to a Venetian Discovery of America. A Criticism and an Indictment.* London: Henry Stevens Son and Stiles, 1898, 233 p., 18 map pls. Copies are in the Clements Library, the University of Michigan Library (rare book room), and the library of the author.
5. Some of these names have changed more than once. Spitsbergen, formerly Svalbard, is again Svalbard, but it appears to have been *Islanda* (Iceland) late in the fourteenth century. The earliest known name of Iceland was *Snaeland* ("Snowland"), next *Gardersholm* ("Garder's Island"), then *Islanda* ("Iceland"), later *Frislanda* (from Friesland, a North Sea province, the name probably given by early Dutch pirates), and now again Iceland.
6. At the Greenland bases of the University of Michigan, compass variation was from 55° to 70° W. At the Pole it is 180°. For other arctic and subarctic localities, the values as of 1905 may be found on map H.O. 1706 of the Navy Department.
7. Evidence of probable volcanic action within this area and hot springs also were discovered first by Nathorst, of the Swedish East Greenland Expedition in 1898. See Koch, L. *Med. om. Grönl.*, **73**, 192 (1929).
8. Lauge Koch reported of these springs (*loc. cit.*): "Along this stretch hot springs occur some distance inland, and there is hardly any doubt that on closer examination a series of ancient volcanoes . . . can be ascertained here. . . . Nathorst pointed out that a volcano must have existed here. . . ." The piping of hot springs into houses in the manner described was employed in Iceland as early as the thirteenth century and was doubtless known to the Preaching Friars, who had shipping connection with that island. Today the Icelandic city of Reykjavik is heated throughout in this manner (V. Stefansson, in *Iceland*, pp. 74–75). Lauge Koch gives the temperature of one of the east Greenland springs as 140°F. in a personal communication to the author.
9. Taracouzio, T. A. *Soviets in the Arctic.* New York: Macmillan, 1938, 227–29.
10. Johnson, D. McI. *Med. om. Grönl.*, **92** (1933); Larsen, H. *ibid.*, **102** (1934).
11. Asphaltum, or "mineral tar," is exceedingly rare in nature. According to the *Index of the Canadian Geological Survey*, there are but four localities for this substance in all Canada, and one of these is at Stellarton in Pictou County, Nova Scotia. This is now hard (asphalt). The district of Stellarton where it is found is known as the "Asphalt District."
12. Throughout Canada caves are uncommon. The only area specially listed in the *Index* is Pictou County, Nova Scotia.
13. He had not passed Islanda, which is on the north side of Frislanda, but the wrong positions of Icaria and Islanda on his map led him to think that an easterly course must have carried him north of Frislanda. He had not seen land and so could not have known.



The Emperor's New Clothes, or Prius Dementat

HARRY J. FULLER

Hans Christian Andersen's story of the emperor's new clothes suggests only one thing to botanist Fuller, faculty member of the University of Illinois—"colleges of education and their constituent prophets and dervishes." His article is based on his address as retiring president of the University of Illinois Chapter of Phi Beta Kappa, delivered at the annual banquet, May 10, 1950. It was repeated by invitation at the Academy Conference, Cleveland (Ohio) Meeting of the AAAS on December 30, 1950.

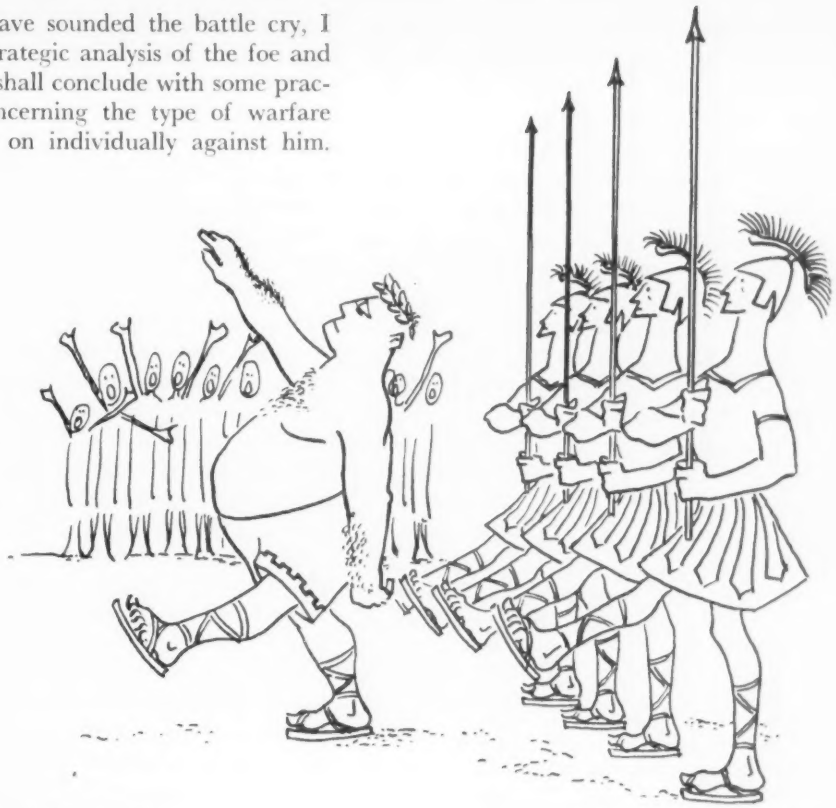
I SHOULD first explain my double-barreled title. I am indebted to Hans Christian Andersen for the first portion of it. Many of you remember his story of *The Emperor's New Clothes,* a penetrating account of the fraud perpetrated upon a pompous Oriental potentate by a pair of astute confidence men. Playing upon the strings of human vanity and conceit, these knaves represented themselves as skilled tailors who, at a monstrous price, fashioned clothing for the high-born from a magical fabric woven only by them and visible only to persons of noble character, unsmirched reputation, and superior intelligence. The scoundrelly tailors, of course, neither wove fabric nor made clothes, but they performed convincing motions of weaving, cutting, fitting, and sewing. And so persuasive were they that the emperor paid them richly with gold for clothes which did not exist, for he feared that his character, his lineage, and his intelligence would immediately be condemned did he admit his inability to see these magical garments. After a lengthy period, during which the spurious tailors enthusiastically swindled the emperor, a royal procession was held to exhibit the magnificent new clothes. The common people, dutifully watching the pageant, were startled by the near-nudity of their undraped ruler, but, like the uppercrust of nobles, fearing that expressions of doubt concerning these wondrous garments would expose them to ridicule, they cheered the king and admired his nonexistent raiment. The fraud was exposed only when a small urchin, unknowing of human vanity and conceit, cried out in a clear voice, "Why, he isn't wearing anything at all!"

The second portion of my bifurcated title is part of a meaningful Latin sentence, "*Quos Deus vult perdere prius dementat,*" which is usually translated as "Whom the Gods seek to destroy, they first make mad." I chose this subtitle for two reasons: first, because I believe that a dash of Latin adds an appropriately dressy touch to a Phi Beta Kappa program; second, because I am hopeful that the pious sentiment it expresses may soon apply to those persons I shall shortly discuss.

You may find all this preliminary chitchat very mysterious, and you are probably wondering what I am really going to talk about—and when. Obviously, the juxtaposition of the emperor's new clothes, of pomposity, and of the activities of the gods in charge of the *Dementat* Department indicates only one possible subject: colleges of education and their constituent prophets and dervishes.

I believe that a discussion of the debasement of liberal education and of sound scholarship by these dreary intellectual sinks and their often dismal practitioners is particularly appropriate at a meeting of Phi Beta Kappa. You who are members of Phi Beta Kappa have a profound interest in the noble creations of the human mind and in the magnificence of the world we inhabit, as they are expressed in the humanities, the arts, and the sciences, and you must become aware, if you are not already, that a sustained attack is being made in our public schools on these great fields of human thought. A crisis is upon us, and all good men and true (and women) of Phi Beta Kappa must rally to the defense of those things for which Phi Beta Kappa stands—the study of the dignity and uniqueness of man and of his creations, as they are made evident in the pursuit of knowledge of literature, of languages, of philosophy, of the arts,

of the sciences. I have sounded the battle cry, I now proceed to a strategic analysis of the foe and of his tactics, and I shall conclude with some practical suggestions concerning the type of warfare that you can carry on individually against him.



The Foe is Analyzed

In my analysis of the foe and his tactics, I shall discuss briefly four topics:

I. The falsity of the basic assumptions from which education professors commonly proceed in their anti-intellectual activities

II. The deterioration in the contemporary training of students, particularly in the high schools

III. The substitution of "societally significant" subjects for sound education in the humanities, the arts, and the sciences

IV. The confusions and inconsistencies that dominate the thinking (perhaps my use of this word is inexcusably charitable), the utterances, and the activities of many education professors

I—The Falsity of the Basic Assumptions

Anyone who has suffered through the standard courses in education or who has, in a spirit of masochism, read the writings of the pedagogical gentry, is well acquainted with what I consider to be their basic assumptions:

a) Education in the past has been largely a failure, and a new era of educational effectiveness has been brought to us by these latter-day prophets.

b) Teachers of the past have in general been poorly trained, ignorant of the psychology of children, repressive, unsympathetic, tyrannical, and, at best, only mildly sadistic, whereas those of the new era (i.e., those who have had a minimum of 20 hours of Education) ooze sweetness and light, understand all the problems of children, are sympathetic, kindly, democratic, and generally possessed of the distilled virtues of Mohandas K. Gandhi, Florence Nightingale, St. Francis of Assisi, Joan of Arc, and Mary Pickford cast as Rebecca of Sunnybrook Farm. As evidence in support of this first of my contentions, I offer this characteristic excerpt from the writings of an education professor:

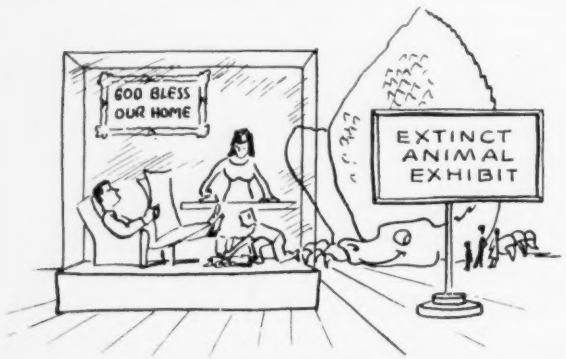
> There was little or no evidence of respect for the individual [in the schools I went to]. Quite the contrary was true. Individual children were constantly subjected to public rebuke; they were made the targets of scorn, ridicule, and sarcasm. We had no freedom of choice in the classroom; we could move from our seats only on permission of the teacher; the teacher told us what to study, how to study it, when to recite, and how to recite. We were not allowed to share our ideas, because whispering was bitterly condemned, and we spoke legitimately only to the teacher, who told us whether our answers were right or wrong. We shared no decisions, because we were not allowed to make any. Such a school may be good training for a Hitler's Germany or a Stalin's Russia, but it is about as poor training for citizenship in a democratic United States as I can conceive of.

c) Education in the past has been concerned

only with knowledge for the sake of knowledge, whereas education of the fresh and dewy present is concerned with knowledge for the sake of living the "full and enriched" life.

d) The American home and American family life are virtually extinct, and, as a consequence, the earnest, young, mimeograph-equipped neophytes of our colleges of education, who, in an earlier and happier time would probably have been primitive evangelists beating the shrubbery for barefooted heathen, must now become wet nurses, instructors in sex education, medical advisors, consultants to the lovelorn, umpires in the battle of the vertical versus the horizontal stroke in toothbrushing, and professors of motor-vehicle operation. I quote again from the writings of an educational wizard:

> Now that youth has been largely withdrawn from real participation in family and community life, it is increasingly falling to the schools to provide experiences that lead to sound moral judgment and the ability to successfully participate in group affairs. We must realize, whether we like it or not, that real participation in family and community affairs is diminishing. The responsibility for providing firsthand experience in activities that are primarily concerned with developing critical and moral judgment is increasingly falling to the schools.



e) Education is a process of fulfilling needs ("Education is essentially need-reduction"), and therefore only those things needed for adjustment in society should be taught.

Rubbish, I say, complete, consistent, and colossal rubbish. The rubbishness of these invalid assumptions, I believe, is obvious to any reflective human being, especially to those who were fortunate enough to attend our public schools before the flowering of our contemporary crop of pedagogical smartweeds. Look back upon your teachers, those of you who are as old as I am, or older. Were not most of them kindly, sympathetic, and understanding human beings? How many of them utilized the techniques of sarcasm, of public ridicule, of psychological and physical abuse, so piteously detailed by the gentleman whose writing I have just quoted?

And what of the assumption that the education of the past was a failure? What of the many fine and wise and noble American men and women whose schooldays occurred before curriculum-enrichment, societally derived need patterns, constellation, and frames of reference became the passwords of the new education? Was their education a failure? Are they psychological misfits, are they ignorant nincompoops, are they incapable of earning a living, of voting intelligently, of bringing up happy families, of pursuing satisfying and refreshing avocations? And what of the assumptions that education is essentially need-reduction and that it should concern itself only with subject matter for which a need is felt? How many students have a need to read and study *Hamlet*, or Wordsworth's sonnet "Composed upon Westminster Bridge," or Matthew Arnold's "Dover Beach," or Willa Cather's *Death Comes for the Archbishop*, or Lincoln's Address at Gettysburg, or to learn something of the awesome wheeling of the heavenly bodies or the intricate, unending biological cycles of our world? Does the absence of a clearly sensed need for knowledge of these things deprive them of value in shaping the thoughts, the ethics, the characters, of young people?

And what of the assumption that teachers of the past (and liberal arts college professors of the present and past) are concerned with knowledge only for the sake of knowledge? Rubbish again. I have never known an able teacher who regarded knowledge per se as the end of education. Good teachers value knowledge for the legacies it can give to the unfolding and training and equipping of human minds and personalities; they know that the study of man's achievements and thought processes in the past, as well as in the present, can offer much that contributes to the enjoyment of life, the improvement of human relations, the building of character, and the evolution of a happier society. True, there are dull and stupid teachers of the liberal arts, just as there are dull and stupid teachers of physical education, home economics, engineering, osteopathy, soil physics, and education. Dull and stupid teachers are thus because they are dull and stupid human beings, not because of the subject matter they teach.

Enough of these false assumptions, the absurdity and meretriciousness of which must be apparent. I proceed now to my second major point:

II—The Deterioration in the Contemporary Training of Students, Particularly in the High Schools

Evidence from many sources supports the va-

lidity of this assertion. College professors generally are aware of this deterioration, which has been rapidly accelerating during the past fifteen years—that is, during the period in which the colleges of education have so pervasively extended their influence over the public schools. As one who is now embarking on his fifteenth year of university teaching, I am well acquainted with this decline in the quality of preuniversity training and, since I first took chalk in hand, I have sadly observed the shrinking knowledge of spelling, arithmetic, English grammar, geography, history, and science in our freshmen. Increasing numbers of matriculating students are unable to write clear, honest English sentences, to prepare logical outlines of materials to be studied or written, to spell commonplace English words accurately, to recognize geographical places, to carry on simple arithmetical procedures, and to use or even name the tools of the simplest mental work. To many freshmen, an English dictionary is a Pandora's box of unknown mysteries and possibly dangerous terrors, to be opened only as an extreme measure. How can one bring order and clarity out of a confused, mangled, and amorphous English sentence, when its author doesn't know what a verb is, or an adjective, or a subject, or a pronoun? Lest I be accused of making an unsupportable charge, I present several bits of evidence. First of these is a commentary upon my elementary botany course written by a university freshman:

> One thing I would like to have is longer hr in discussion period Lot of time we discuss a chapter after we had our lab work that a great help. Why can we have discuss on chapter than lab work what we discuss not before than In lab some time we don't know what we are looking for cause we did have discuss or read a text. Botany as a whole is very interesting, If we understand what we are doing and read, that is the reason we need longer hr in discuss Botany is very interesting subject to learn. It will help a person lot to understand a plant life. Lab work in Botany was interesting to some time it was hard but I did care. that is call college.

Here is another literary gem, this from a high-school senior:

> We have been studrying about how a human being reproduce. I would like to know if you have idental twins if one twin can't reproduce. I know one of them can but can the other one. When you have idental twins they half to be 2 boys or 2 girls it can't be a girl and a boy can it.

And here is another golden moment, from an elementary botany examination paper:

> A onion is a blub or modyfied stem. They are dormaceous you find them underground. you also find modyfield stems like the tumors of a potatoe plant. It is also underground and you find food in it, a lot starch but not much protien.

I could cite you many more such examples, but I comment only that, in the early 1920s, when I was a high-school student, my classmates and I should never have been graduated had we achieved no greater facility or accuracy in the use of our native language.

The deterioration of which I have spoken is not limited to the use of English but is evident in other fields of human knowledge, such as arithmetic and geography. The objective of one of the laboratory operations in my elementary botany course is to give students some conception of the sizes of plant cells. Students are told that the diameter of the circular microscope field which they see when they peer into the eyepiece is 1.5 mm. They then observe small pieces of plant tissue mounted on the microscope, and are instructed to count the number of cells that stretch across the diameter of the field, then to calculate the approximate length of each cell. Knowing that the diameter of the field is 1.5 mm, and observing that three cells extend along this diameter, 40 per cent of the freshmen in general botany cannot determine the length of these cells. They simply murmur ashamedly, "I never was good in arithmetic."

The awareness of this deterioration is not confined to university professors, who, after all, since they are professors, are generally believed to hold outlandish and loopy views on most subjects. During the past ten years I have pursued, on trains, and in planes, hotel lobbies, barbershops, and soda fountains, a private research project among businessmen and practitioners of the law, medicine, and other professions. My research technique consists merely of asking for answers to a standard battery of questions in my best quasi-Kinsey manner. Answers to my questions have furnished me

TABLE 1

HIGH-SCHOOL GRADUATES OF THE PRESENT COMPARED WITH THOSE OF 25 YEARS AGO*

	Arithmetic	Written English	Spelling	Geography	World Affairs	Poise	Manners
Inferior	81	65	68	60	39	31	57
Same	22	33	32	38	37	32	33
Superior	3	8	6	4†	30	43	16

* Number of persons interviewed: 106 (19 states), representing 18 types of business, 3 professions.
† Indicates 4 not answering the question concerning geography.

data (Table 1) that support the unhappy conclusions of the professors concerning the growing ignorance of our young people. The implications of these data are obvious: that, although our high-school graduates may have more self-assurance and more poise than those of a quarter-century ago, they are consistently deficient in those mental achievements that we customarily associate with an intermediate degree of education.

My point is further supported by incredible and appalling information given me by a colleague who served for three years during the war as educational director of a major American airline. In his work of selecting and training girls, all high-school graduates, as ticket sellers, reservation clerks, and flight stewardesses, he found it necessary to organize special classes to instruct them in the esoteric mathematics of making change and in the salient geographical features of their native land. Only a small proportion of these girls, all armed with high-school diplomas, and many of them honor graduates, could place Boston, New York City, Cleveland, Chicago, Kansas City, Denver, Salt Lake City, and San Francisco in their proper sequence from east to west, or name the states in which they occur; few indeed were those who could with accuracy and celerity calculate the amount of the 15 per cent transportation tax on tickets; and many were those who could not name the lake against which Chicago nestles or the river whose mouth is guarded by New York City.

The increasing failure of our public schools, under the stupefying meddling of our colleges of education, to provide young Americans with sound knowledge and training in the tools and intellectual methods of educated people, is tragic and ominous indeed, but it is perhaps less tragic and less ominous than their contribution to moral and ethical deterioration of the students entrusted to them. A strange and wondrous product of certain professional pedagogical minds is the teaching that the principal requirement for graduation from high school is length of classroom residence. According to these high priests of pedagogy, failing a high-school student in his courses, or refusing to graduate him if he does not achieve a creditable proficiency in his studies, may engender in him profound and permanent psychological aberrations, which will doubtless lead him into a life of crime, a career as a scribbler of obscenities on washroom walls, or a sticker of thumbtacks into his mother-in-law. Therefore, they cry, let us give a diploma to everyone who manages to sit in high-school classes for four years, whether or not he has learned anything. This practice recalls a conversation between Alice, during her brief but pleasant sojourn in Wonderland, and the Dodo, who remarked following the caucus race, "Everybody has won, and all must have prizes."

An old friend, who for thirty years has taught a physical science in a high school in a large Midwestern city, has told me of his experience in this connection. In the days when his school administrators were scholars, he failed those students in his courses who were unable, through lack of ability or application, to master 60 per cent of the subject matter of those courses. Now, with the school system in which he works supervised and managed by masters and doctors of education, he has been subjected, first to persuasion, later to tremendous pressure, to eliminate his old-fashioned practice and to pass all his students. Upon his insistence that students who don't work and, as a consequence, don't master his courses, should not be passed, he has been the recipient of heart-to-heart talks from his principal and of elaborate forms to be filled out for each failing student, forms which require hours of work and a degree of insight and knowledge that few psychoanalysts possess. As a result of these pressures and demands, he has knuckled under, as have his colleagues, and now passes all his students, whether or not they have learned anything.

What is the moral effect of such educational chaos? The lazy, the incompetent, the procrastinating student soon learns that he will get by without working, the able and industrious student learns with disgust that the rewards of his industry

and achievements are the same as those of the dullards. A corollary of this fatuous principle is the teaching of certain moonstruck pundits that absolute grading scales should be abolished and that each student should be graded according to his individual capacities and the relation of his learning to his capacities. Thus, if a student who has achieved a distinguished level of feeble-mindedness turns in the maximum performance expected of topflight feeble-mindedness, he should receive an A for his work, for he has done all that he could. Similarly, a superior student, with an IQ of perhaps 130, is given an A when his performance approximates that expected of conspicuously brilliant students. Thus, both the poor semi-idiot and the near-genius may receive the same grade for the same course—but what of the disparity between their absolute degrees of achievement? The effect of these incredible stupidities is eminently to *un*prepare students for adult living. The incompetent and the lazy, trained to expect rewards without labor, are likely to develop the too-prevalent conviction that the government (i.e., their more industrious and abler fellows)—owes them a living, without the necessity of honest hard work and the discharge of reasonable responsibilities on their part. The good students, logically enough, are fertile ground for the germination and fruition of the same attitude. And the prophets of the new faith boast that our schools are now preparing students for life!

The educational practice I have just described is certainly one cause, together with others I shall mention in a moment, of another type of deterioration that is happening to our high-school students—the decrease in their tenacity, the dwindling of their mental guts. Most of our present university freshmen have never confronted a really difficult mental problem, or, if they have, they have not been compelled to stick with it until they have solved it. Every high-school student who marches through the potted ferns and palms to receive his diploma should have been compelled to acquire a strong and tenacious discipline in some one field: science, language, history, dramatics, automobile mechanics, or bookkeeping. That is, he should have been told by a teacher, "Here is a series of problems in the field of your major interest. I want you to solve them. I'll offer you aid and advice from time to time, but I want you to prove to me that you have the courage and resolution to tackle these problems and to stick with them until you have solved them. If you try to solve them but don't succeed in working all of them out you will have my commendation for a courageous attempt."

Unfortunately, few high-school students at present receive such truly valuable experience. They flit from overview course to capstone course, sipping here and there, they engage in a variety of social experiences, many of them of no depth or breadth and of little consequence, and they approach the problems of life with no real experience of hard, toughening mental work or of intellectual stamina. A. J. Carlson, the grand old man of American physiologists, now professor emeritus at the University of Chicago, said essentially this in a recent address before the American Association for the Advancement of Science: "We see mental and moral weakness increasing everywhere about us, in our poorly and frivolously trained students, in our divorce courts, in our criminal courts, in our governing officials, at all levels in our civilization. As a physiologist, I know of a specific chemical remedy which would check and ultimately eradicate such mental and moral flabbiness from us. That chemical is a simple one: iron, iron in the backbone." Certainly, our high schools are putting some chemical substances into our students, mostly whipped cream and marshmallows—but are they really furnishing any iron for the backbone? I believe that most of them are not.

"Societally Significant" Subjects

And now for Point III—the substitution of "societally significant" subjects for sound education in the humanities, the arts, and the sciences. Within the past twenty years there has occurred in our high schools an extensive de-emphasis of courses in languages, the sciences, literature, and history, in favor of a grab bag of new, "societally derived" courses, such as social behavior, how to win friends and influence people, how to succeed in marriage, air science, family life values, being an effective consumer, group dynamics (whatever this may be), occupational adjustment, zeal for democratic processes, directed activities, and other such windy and vacant substitutes for thought. Often the wily proponents of the new education, instead of instituting such new intellectual *pièces de résistance*, simply execute a fifth column stratagem, using the old course names, but destarching these courses of much of their sound educational content and value. Thus, rhetoric and English literature may still appear under those names on the books, but their content may become "communications arts," a mélange of hints on radio acting, writing advertising copy, evaluating political speeches, persuasive salesmanship, and the limpid beauty of the works of H. V. Kaltenborn and John Gunther. Biology courses may still bear the tag of biology, but

their content is often reduced to personal hygiene, what to do about forest fires, how to breed better corn and sheep, stream pollution, what I should know about dysentery, pollen grains and allergies, and what shall we do about the disappearing flat-breasted nitwit and other game birds? Gone from many such biology courses are the basic, the impressive, the truly significant biological phenomena: the panorama of life through geological time, the marvelous interrelation of tissue structure and function in living bodies, the wondrous adaptations of flowers to pollinating insects, the mysterious migrations of birds, the beautiful precision of the hereditary mechanism of cells, the carbon and nitrogen cycles. Physical science, too, has suffered its debasement, and now, in many schools, is devoted largely to what makes a doorbell ring, the ups and downs of elevators, where to drill for oil, what the atomic bomb means to me, how to build a hydroelectric dam, and why not to put pennies in fuses. And so it goes. The extent to which sound knowledge has been replaced by drivel is illustrated by this excerpt from a letter which reached my desk a few days ago: "I am interested in securing a college position teaching methods of instruction. I received the M.A. degree from ——— University in Guidance."

Persons of education know (perhaps that is why so many education professors do not), and have known for centuries, that languages and literature, the arts and the sciences, constitute a rich, imaginative, concrete, and enduring source of valuable lessons in manners, ethics, behavior, personality development, beauty, and social adjustment. Under the guidance of able and wise teachers, students may extract from the study of the rise, decline, and fall of Rome, of *Hamlet* and *Lear*, of the lives of plants and animals, of Homer and da Vinci, of Mark Twain and Rousseau, facts and precepts that can mold their characters, broaden their minds, make of them sound and mature citizen-adults. Perhaps a line of Bernard Shaw's is pertinent to the antipathy of many education professors to these classical fields of human knowledge: "People who are not up on a thing are usually down on it."

I do not wish to imply that the humanities, arts, and sciences should constitute the sole subject matter of high schools. I believe that certain social service courses have a valuable function in the education of young people, but I am convinced that the burgeoning of such courses has been excessive and beyond the limits of their value. I do not object to a small, well-planned aggregation of these courses, but I am ready to buckle on my

armor when the effect of such courses is to emasculate and vitiate the humanities and the pure sciences, on the assumption that the former are empty, moribund, and irrelevant relics of the past and that the latter are simply incidental to our contemporary invention of mechanical gadgets, jet planes, and atomic bombs.

Chaos Indeed

I now tackle the last of my four major points: the confusions and inconsistencies that dominate the thinking, the utterances, and the activities of the education professors. On this subject I could write endlessly, with only brief pauses for refueling, but my space is running out and I can touch upon only a few of the inconsistencies and confusions of the pundits:

a) We are told by them that one of the functions of modern education is to bring students to a high level of "communications skill," to teach them to express themselves in their own way, to organize their thoughts orally or on paper. Yet the education professors have spawned examination questions (perhaps, to be modern, I should say "evaluative techniques") that may be answered by blackening spaces with soft lead pencils, or underlining words, or writing *T*s and *F*s, or punching holes in cards with conductor's punches—in other words, which require neither writing, nor organization of thoughts, nor self-expression, nor discrimination.

b) We are assured that this is an age of internationalism, that we must study and understand the peoples of other countries and their civilizations, activities, and creations, that we must all work together for better understanding and cooperation among nations. At the same time, many of the soothsayers who promote these tumid sentiments are engaged in a campaign, both in high

schools and in universities, to depreciate the study of the most effective means of our communication with other peoples—namely, foreign languages.

c) The confusions and inconsistencies of the education professors are mirrored in the strange and preposterous dialect they employ to communicate with one another and to bamboozle timid school boards. Apparently in the intellectual demimonde in which many of them have their being, precise, standard English is incomprehensible. Thus have arisen the rich, purple prose and the grandiose and bombastic vocabulary they are wont to use. Many of you are acquainted with this flamboyant and turgid vocabulary. In the event you are not, I happily and fiendishly toss a few samples your way: implementation, frame of reference, differential environmental pressures, followership, sweep courses, capstone courses, overarching responsibilities, enriched curricula, bench marks, constellation of principles, in-groups and out-groups, active passivity, creativity, etc. I should like also to offer a few examples of the clear and definitive writing of some of these principle-constellators:

> The purposes of this course are to provide in a sense a capstone course in the training of teachers of biological sciences. Approximately sixty percent of the time of the course and its prime objective, is to review the broad fields of biological sciences that appear to be pertinent to the function of a secondary school teacher. This review considers not only such areas as the nature of the cell, metabolism, and other life functions, etc., but as well such areas as ecology, human physiology, conservation of biological resources and similar more functionally designated fields. . . . One of the greatest problems in the preparation of high school teachers is to provide in a short period of time available, along with a general education of worth for the person as an individual and a citizen, and a leader of young people, a real understanding of his sciences with sufficient penetration to make his understanding real and usable and with sufficient coverage to avoid gaps of importance to the ultimate student's [just what is an ultimate student?] interests and needs. This course does provide for, in a sweep fashion, a coverage to pick up possible gaps [this presupposes some facility, I believe, in gap-picking] to give him some sense of structure and perspective in regard to the broad fields of biological sciences.

Here is another equally beautiful example of restrained English prose, a description of a course in education:

> Education—: Principles of Education in the Public Secondary Schools. Designed to acquaint students with the major problems, issues, and challenges faced by the public schools as a consequence of the fact that the schools are a social force interacting with other significant social forces. Designed also to provide each specialized educational worker with a common orientation as to the major responsibilities of the public school as a unit and his own specialized responsibilities and problems within the framework of the total educational enterprise.

Degassed, this flatulent prose means simply this: that schools are important social agencies, that they have problems and responsibilities, and that teachers should know something about these.

I continue:

> Professor Blank will talk on "Norms of Education Success: Semantic Maturity vs. Life Adjustment." . . . His talk will be based on a study made during the past years concerning the logical conditions which must be satisfied in order that students may actually "know" what they are learning. He has defined knowledge as the beliefs which students can use as a basis for adjustment to life.

As though this were not enough, I cite still another clarion call, distinguished by its clear thought and succinctness: "The present is the link between the past and the future, and we must educate accordingly."

This one, somewhat more verbose, is equally precise:

> The first important item in the redirection of school administration is that of keeping it faced toward the future. As this is done, the emerging patterns of the secondary school will fit more and more into the emerging pattern of society rather than continuing to remain outside of it.

My last quotation of this group presents relatively straightforward English but, with it, a considerable degree of positional and arithmetical confusion:

> The test may be taken in a group or individually. If taken alone, it is desirable to caution the subject against answering it in collaboration with others, or against spending too much time on it.

What is the basic reason for the existence of such jargon? Is it the intellectual equivalent of whistling

in the dark? Is it a brave and rococo façade, designed to hide a bleakness of thought, a paucity of ideas, an envy of people who really have something to talk about, a gnawing feeling of inferiority? The answer I leave to you.

d) Another indication, I believe, of the confusion and uncertainty that prevail among many education professors is the transitory and unstable quality of their interests and loyalties. They seem eager to disavow the knowledge and thought of the past, they are in love with the rapidly shifting present, and they are constantly relating themselves and their doings to fads and to the new things of our time. Witness the number of pedagogical exhortations on such subjects as "Education in the Age of the Atom," "Living in the Air Age," "Air Science," "Atomic Power and the New Education," et cetera. And what of the unassailable logic of those professors who preach that, since this is the air age, one cannot become a "fully implemented teacher" unless he has had a ride in an airplane and who therefore insist (certainly with no thought of the attendant publicity value) that their students must have plane rides? One thing that disturbs me is the apparent slight given the rocket age. We spent a year or two educationally drooling about the airplane age, we are now thumping the drums for the atom, but we seem to have ignored the rocket. We have also failed to give the antibiotic age its due, but, after all, what is the "attention-focusing" value of antibiotics as compared with that of swooping planes and merrily popping atoms?

Meeting the Enemy in Combat

I have now completed the discussion of my fourth and last point, and I am in the stretch. My attack has been vigorous, and, in view of the generalizations that limits of space have forced me to make, I may have oversimplified some of my points, possibly to the extent of appearing unfair. I do not wish to suggest, for example, that the humanities, the arts, and the sciences are sacred and therefore not open to question and criticism, or that they are always well organized and well taught, or that their teachers are always able and mellow and scholarly leaders of youth. Nor do I wish to leave the impression with you that I believe *all* education professors and their courses and activities to be hopelessly idiotic. There are some education professors who are gentlemen and scholars, with high intellectual and educational standards. At the base of much of the educational mumbo jumbo is sometimes a solid subsoil of sound and helpful educational practice and psychology, much of it the work of this minority of able education professors. Too often, however, this subsoil remains invisible under a cloud of murky and swirling dust, raised by the hot winds that emanate from the numerous educational opportunists and carpetbaggers who too often dominate our colleges of education and our public schools. What I am arguing for is the restoration of the humanities, the arts, and the sciences to their properly dominant position in our educational system and for the elimination from our schools of the silly fads, the tawdry tricks, the superficial subject matter, and the cheaply utilitarian educational philosophy forced upon them by some education professors.

I am sure that we all want our high schools to do four things: to give students some vocational tools that may aid them in earning a living; to give them knowledge of the social and economic problems of our civilization, with necessary guidance in their own social problems and adjustments; to give students mental fortitude and the ability to reason out difficult problems with discrimination, accuracy, and thoroughness; and to give them a knowledge and an appreciation of the uniqueness of man, of the splendor of his creations, and of the laws of nature. Our schools are doing the first two reasonably well, they are becoming increasingly ineffective in doing the last two. If we give proper emphasis to the arts and sciences and humanities, and if we utilize those truly sound educational practices devised by both sane education professors and superior teachers of the sciences and humanities, then we shall have a good start toward achieving all four objectives.

In conclusion, I want to tell you how you can aid in our struggle. Some of you will, within the next decade, marry and become parents. Some of you are parents now. When your children enter school, join your PTA, which is often merely a lobby manipulated by some college of education and which may require the aid of parents of character and wisdom and learning to ensure sound and decent education for our children. When PTA speakers, often education professors on tour between principle-constellations, or your school principal, who is probably an M.A. in Education and therefore possibly suspect, suggests, as one visiting speaker recently did in a Champaign (Illinois) PTA meeting, that the imparting of knowledge is no longer a major function of the public schools, rise in righteous wrath and organize your neighbors to put him in his place. If your family and business obligations permit, run for your school board, and, if you are elected, be watchful of attempts to cheapen the educational processes of your com-

munity. Further, follow carefully the work of your state legislature and indicate to your local senator and representatives your opposition to any increase in education course requirements for teacher certification in your state. Attempts are made from time to time to increase such requirements, chiefly at the behest of the powerful professional education lobby. This lobby exerts its great power partly through its hold on public school administrators, partly through its numerous professional education journals (the University of Illinois library receives 146 professional educational journals). That citizens are becoming increasingly dissatisfied with the present work of the public schools is everywhere evident in private conversations, in PTA discussions, and occasionally in the press.

In using the tactics I have suggested, I urge that you not underestimate the power and arrogance of the foe. Listen to this:

> As a rule, parents wish only the best of school conditions for their children; determination of what is best is, however, not a matter for parents to decide, but is the responsibility of the regularly constituted school authorities. It is all too easy for parents, particularly when organized into an association, to get the idea that schools are conducted for their especial benefit. An organization of this type performs a useful service *in acquainting parents with the plans, policies, and procedures of their schools. If parents do not like a public school, they can remove their children from that school and place them where conditions are more to their liking.* (Italics mine.)

This example of neo-Hitlerism is a pronouncement of one of the leading Brahmins of American education, an implementator at the University of Chicago.

As I taper off, I hope that the significance of my title is clear. We have bought the emperor's new clothes; may we soon more widely recognize them for what they are. Whether the gods will fulfill the promise of the Latin proverb, I do not know. They've done pretty well with the *dementat* part. It remains to see whether they will make good on the *perdere*. While there's life, there's hope!

On the Artificial Production of Stupidity in Schools

It is related of a learned judge, that he once praised a retiring witness in the following words: "You are entitled to great credit, sir. You must have taken infinite pains with yourself. No man could naturally be so stupid."

We cite this well-worn anecdote because it contains, probably, the earliest public recognition of the principle which the title of our article is intended to convey. Existing in all ages of the world, in all conditions of life, and described by a copious vocabulary in every language, stupidity is something which it has never been possible to ignore or to forget. The fact of its all-pervading presence, its vitality in the most different climates and scenes, has tended to convince mankind of the necessity of an evil which they have never failed to perceive; and which has served, from time immemorial, as a subject for the lamentation of the wise, and a basis for the calculations of the designing. The lessons of proverbial wisdom, the results of hasty generalization, and the daily experiences of life, all point out, or seem to point out, that stupidity is inseparable from the existence of the human race; and that it must appear, not in every individual but in many individuals, of every community. It follows that the persons in whom the phenomenon is most conspicuously manifested are regarded with something of the compassion which attaches to physical infirmity; and enjoy, in a certain degree, the power of blundering, with the privilege of being exempt from punishment.—*Pop. Sci. Mon.*, **1**, 129 (1872).

Positive Role of the Social Scientist in the Point Four Program

AFIF I. TANNOUS

The author, who is regional specialist for the Middle East in the Office of Foreign Agricultural Relations, Washington, D. C., was born at Bishmizzeen, Lebanon, and educated in the schools of his native land. He took his Ph.D. in social science at Cornell, however (in 1940), and began his work with OFAR in 1943. Previously he had worked in Syria, Lebanon, Palestine, and the Sudan. Dr. Tannous' article is based on a paper delivered before the Denver meeting of the American Sociological Society and the Society for Applied Anthropology.

IN HIS inaugural speech, early in 1949, the President of the United States discussed four items of national policy. Under the fourth point (hence, the Point Four Program) he announced to the world the proposal of a "bold new program" of technical assistance, with a view to developing the resources of underdeveloped countries and helping them enjoy higher levels of living.

Since the announcement of that proposal, which is tantamount to the declaration of a major new orientation in the foreign policy of the United States, an unusual amount of thinking, discussion, writing, and planning has been devoted to the subject. We have witnessed this active response, not only in the United States, but also in Europe, and in the vast regions of Asia, Africa, and Latin America, where the program will be in operation.

Much spadework has been done by the State Department and other interested governmental agencies, with a view to giving this new, positively aggressive policy a defined form and tangible substance. Generous space has been allotted by the press to the expression of public opinion on the proposal. A large number of private professional, educational, religious, and other groups and organizations have given serious consideration to the implications of the Point Four Program, through lectures, conferences, panels, and symposia. Regional conferences of foreign service personnel have been organized in various parts of the underdeveloped world by the State Department, in cooperation with other governmental agencies, with a view to doing the necessary groundwork for the local implementation of the program. The United Nations Organization and its directly concerned agencies have manifested equally serious interest in this constructive world proposal by deciding to participate actively, both financially and technically.

Finally, after due consideration, Congress, voicing the opinion of the majority of the United States people, passed the bill authorizing the operation of the Point Four Program, on May 25, 1950. On June 5 the President signed the bill into a law entitled *Act for International Development.* Congress appropriated the necessary funds on September 6, 1950, and the implementation of the program in the field is now under way.

Thus the first stage in the fulfillment of the new policy that was proposed about two years ago has been achieved. We are now in a position to see more clearly through the reverberations, critical or favorable, caused by the proposal, and come to some pertinent and pointed observations and conclusions.

1. It is certain, contrary to what a few still believe, that the technical aid policy was not formulated and proclaimed more or less extemporaneously, in an off-the-cuff fashion. It was the result of serious study and thought on the part of many people sensitive to the real issues at the bottom of world tensions. It was the result of several years of experience in the extension of technical aid in

Latin America and in other parts of the world, both by governmental agencies and by private voluntary organizations. It was in reality a direct and simple, yet potent, answer to the challenge posed by the urgent need of the world for the establishment of stability and peace.

2. The global significance and serious implications of this proposal have been amply demonstrated by the keen interest and great hopes it has aroused in the United States, at the United Nations, and among the leaders and peoples of the countries that need the assistance.

3. Thus we can objectively conclude that for about two years the idea has been put to a thorough test of discussion, criticism, and appraisal at the hands of the public and the available national and international leaders, and that it has emerged more seasoned, more clearly defined, with more tangible content, and, above all, overwhelmingly desired by all concerned.

4. As regards the basic objectives of the policy and methods of operation, the law clearly emphasizes the following:

a. That ". . . the United States and other nations have a common interest in the freedom and in the economic and social progress of all peoples."

b. That such progress as achieved in the underdeveloped countries will be mutually beneficial to all concerned.

c. That it is the policy of the United States to aid the efforts of such countries to develop their resources and raise the standards of living among their peoples.

d. That the two major channels for such aid will be the exchange of technical knowledge and skill and the encouragement of the flow of needed capital.

e. That the program will be undertaken cooperatively, with the receiving country contributing a fair share of the required personnel and facilities.

f. That some projects will be undertaken multilaterally through the United Nations, and others bilaterally, through an agreement between the United States and the other country.

g. That the participation of private persons, agencies, and institutions in the program shall be sought and facilitated by such means as grants-in-aid, specific contracts, the creation of an advisory board of representative and professionally qualified citizens, and the appointment of committees in specialized fields.

5. From this brief background statement, we come to the pointed conclusion that the Point Four idea has assumed the form of an extremely significant and challenging reality. It is an avowed policy of the United States government and people, supported by a definite law and by appropriations. Whether it will ultimately attain its major objective of creating prosperity and socioeconomic stability in a large portion of the world, and thus further the cause of democracy and peace, will depend to a large extent upon the backing it will get from the people, institutions, and professional personnel of the United States and of other advanced countries.

This brings us straight to our major point of interest—the place and role of the social scientist in this activity. Is he equipped to make definite and positive contributions to the program? Are his contributions basic and essential? If so, it is his duty as a citizen and a scientist to take the initiative and make his voice heard. So far, with a few outstanding exceptions, he has said and offered relatively little. In the following paragraphs I shall attempt to present his case within my limited knowledge, with special reference to the Middle East, one of the major regions involved. It is my earnest hope that other members of the various social science disciplines, better qualified than I, will respond to the challenge of this new national policy, and state in clear and positive terms the contributions the student of human behavior could make.

In my judgment, there is a real and urgent need for the development of such a statement, positive, coordinated, and pointed. There is essential need for the social scientist to be actively implicated in the program from the beginning. Otherwise, any project of technical aid will run a grave risk of being disrupted, and possibly wrecked, by the ignored forces of local culture, or of creating in the long run more problems than it will have solved.

1. The first basic need that the social scientist is well qualified to meet is the undertaking of related and persistent surveys and research in the local culture. We need to know the organization of its communities, groups, and institutions, its basic values and aspirations, its underlying tensions, its trends of change, before we can safely recommend technical projects for the solution of its problems.

In Saudi Arabia, in Syria, in Iraq, and in Iran, for example, the nomadic and semisettled tribal way of life is either predominant or highly significant in the total economic, social, and political organization of those countries. It is a societal system that is several thousand years old, with deep-rooted traditions and patterns of behavior. At the same time, we find that the knowledge we possess of this type of human organization—i.e., authentic and reliable knowledge—is certainly meager; it is limited to a few classical and temporary studies that are excellent. To be sure, there is a wealth of romantic literature about the nomads of the desert, and there are many superficial observations about their way of life. We cannot depend upon such notions to be our guide in the extension of technical aid to those groups; and any technical aid project

will have to be concerned directly or indirectly with the tribal organization in most of the countries of the Middle East.

Stated in more specific terms, the planners, administrators, and technicians of the proposed aid program need to have satisfactory answers to such important questions as the following: Is agricultural settlement (which has become a national slogan in most of these countries) through the development of large-scale irrigation schemes the most effective way of solving the tribal problem? Will the destruction of the grazing economy of the tribe, which makes efficient use of scanty desert growth, result in a net gain or loss to national economy? Are there in the tribal culture certain basic values that should be preserved for the total national culture? How far and how rapidly could the tribal community be transformed into an agricultural community, and by what techniques and methods? What are the chances that such transformation will result in deterioration of health and morale, and in general disorganization? What about the basic land tenure aspect of the matter, which is already the major problem of the Middle East? Will such a program ultimately result in transforming the tribal chief, a democratic leader in the nomadic setting, into a feudal lord, and his tribesmen into landless sharecroppers?

These and other basic questions apply with equal validity and pertinency to the village community of the Middle East. Taking the region as a whole, we find that the way of life is overwhelmingly agricultural, based upon the village as a clearly defined unit. It has folkways and mores, deeply rooted institutions, and various ways of behavior, all its own. We find those highly interrelated and integrated into a general and well-defined organization. It is mainly in this all-important agricultural village community of the Middle East that the technical aid program will be applied; and it is at the hands of its people, who constitute the great majority of the total regional population, that the program ultimately will succeed or fail.

Here again, we face the reality that what we know about these village folk and their way of life is fragmentary and inadequate. What are the basic values that are most dearly cherished, and what are the dominant institutions? What are their basic attitudes and prejudices? Is this or that village relatively more ready to absorb technical change, and why? In which one or more of the proposed projects are the people more willing to participate? What are the basic appeals through which the people can be made to go along with the program? By what means could the proposed material aid be translated into higher standards of living? More basically, what standard of living should be defined for this or that community? What are the chances that this or that technical project might result in destructive disorganization of community life, and by what means could such a development be avoided?

It is my conviction (based mainly upon experience in action programs in the Middle East) that such vital questions can best be answered by social science. The successful application of the Point Four Program calls urgently for the services of a team of social scientists. They would undertake fundamental research in the local cultures involved, integrate their findings, and present from time to time coordinated and pointed statements for the guidance of the program.

2. The second essential contribution the social scientist can make is to keep in close touch with a certain technical aid project that has been applied, and make periodical appraisals of its development and effects. No matter how carefully a project is selected, and how thoroughly the ground is prepared for it to fit into the local community and into the total culture, unforeseen developments will always arise. This is so because of the dynamic nature of technical change, especially when it is applied to such as the Middle East rural culture, which is highly integrated and stabilized. Reverberations in seemingly remote aspects of the culture will occur, and relatively new situations will develop. A reappraisal of the original project, together with modification of the method of approach, will be necessary. Without the benefit of such appraisal and timely adjustment, the project will run the risk of being wrecked by accumulated tension, or of leading to a point far removed from its original objective.

The comprehensive land reform project that was planned and applied by the Ottoman government during the second half of the nineteenth century affords a classical illustration of this principle. The essence of that technical project was to divide the vast state domain among the landless peasantry of the empire, and thus create a solid class of small owner-cultivators. It was a direct attack at the then prevailing feudal system. The necessary laws were enacted, and the required administrative and technical machinery was set up. After about three decades of application of the project in Iraq and in neighboring provinces of the Empire, the Ottoman government realized that it had met with almost complete failure. What happened was that, instead of attaining its original objective, the program was so influenced by local economic factors

and social forces, and by newly arising situations, that it actually became the means for increasing the domains and power of feudal lords. It also brought about a state of acute disorganization and bloody conflict among the people.

In the first place, some of the tribes refused, from the beginning, to accept such land grants from a remote government and settle down; they were suspicious of the motives behind the program, and they preferred to pursue their traditional independent way of life. Anyway, they had been using the land for grazing and some cultivation for centuries, without the benefit of a grant from the government. They challenged the right of the central authorities to have any claim on the land. When the government attempted to assert its authority, rebellion and bloody fighting ensued.

Second, when some tribal chiefs or subchiefs were induced, by one means or another, to cooperate in the project, they were considered as traitors by other chiefs. Again, this intensified intratribal and intertribal conflict and disorganization.

Third, as the land law clearly stipulated that alienation of state land was to be made to individuals and not to groups, upon proof of a period of occupancy, its application proved impossible in the majority of cases. Tribal territory, and in many cases village territory, were utilized collectively; no one individual could prove his exclusive occupancy right with respect to a specific piece of land. This was a wide loophole through which tribal chiefs and other influential people were able to defeat the original purpose of the law. They succeeded in registering the land in their names, in behalf of the whole tribal or village community. Gradually, but surely, they were transformed into absentee landlords and their kinsfolk into deprived sharecroppers.*

We have dwelt upon this case not only because of its value as an illustration, but also because of its significant and direct bearing upon the present situation in the Middle East and upon the application of the Point Four Program in that region. The grave land tenure problem of the Ottoman Empire is still today the major and basic issue in most of the countries of that region. If it has changed any, it is only in the direction of becoming more acute and explosive. The same factors of tribal and village organization, the same social and economic forces that were operative in those days, are still in full sway there. They are ready to influence and engulf any project of technical aid that is aimed, in accordance with the letter and spirit of the Point Four Program, at the achievement of economic development and higher levels of living for the people of the country concerned.

Again we have to turn to the people best qualified to tell us what these forces and factors are, how to appraise their roles, and how to guide the course of the aid program, with a view to having it achieve its intended objective. We need the services of the students of sociology, economics, history, political science, culture, education, and other selected fields in order to accomplish our task successfully.

Before leaving this aspect of the discussion, I feel urged to raise a few pertinent questions with respect to Saudi Arabia, a country that is moving rather rapidly along the road to modernization. Its way of life is predominantly tribal and nomadic, with minor agricultural activity. Its benevolent government, again basically tribal and Islamic in organization, is all for the introduction of Western technology in agriculture, communications, and other aspects of the country's life. The Arabian-American Oil Company, which holds the huge oil concession in that country, wisely conceives of its mission and responsibility as more inclusive than the mere development of a natural resource, and is actively assisting in the process. An Egyptian mission, three U. S. missions, and more recently an FAO mission have visited the country and rendered assistance in the utilization of water for irrigation and in the expansion of agriculture. Furthermore, Saudi Arabia is expected to be the object of technical assistance to be rendered by the U. S. and by the United Nations Organization.

In other words, we witness here a country making a dramatic and drastic departure from a tribal way of life, with a pastoral economy, into a national organization that is based upon agriculture and related industry. The consequences of such a move will certainly be grave; and one with a feel for the historical perspective of the Arab world and for cultural dynamics cannot escape raising such serious and pertinent questions as the following: What effects will these technical projects, already begun or proposed, probably have upon tribal and national organization? Are those effects really desired by those concerned? If not, what methods and techniques could be utilized to obviate them? As the irrigation projects now under way are realized and expanded, on what socioeconomic basis will they be operated? Private family ownership of the land, collective community cultivation, or large-scale absentee ownership? Which one of

* This subject is ably discussed by Dr. S. Haider in *Land Problems of Iraq* (unpublished Ph.D. thesis, University of London, 1942).

these is in the best interests of the country and in keeping with the spirit of the Point Four Program? Are the independent, virile, and essentially democratic tribesmen of Saudi Arabia likely to fall victims to a state of demoralization, loss of cultural values, and economic deprivation, as has happened in the neighboring countries? If this is to be avoided, what techniques, laws, regulations, and policies should be adopted?

Who is going to provide the best possible answers to these and similar questions, now and as the process of development marches on? It is my suggestion that it would be unrealistic to expect the technician, be he an engineer, an agronomist, a soils man, or a machinist, to do this basic job for us. Nor would it be fair to hold him responsible for the possible ultimate failure of his technical project to attain its original socioeconomic objective, or even to function smoothly in the hands of local cultural groups. This is a task that must be undertaken by additional personnel, especially trained and qualified, who would work hand in hand, step by step, with the technicians and the administrators of the program.

3. The Point Four Program, as clearly stated in the *Act for International Development,* briefly discussed above, rests squarely upon the premise that it consists essentially of a positive and constructive message from Western democracy to the underdeveloped areas of the world. The need is obvious, therefore, for a clear, unified, and agreed-upon definition of what Western democracy is, what it stands for and what it attempts to do. To be sure, we have many definitions of the democratic ideology, much literature on its development and principles, many common-sense notions on how it works in various situations of daily life. But this is not sufficient for our purpose; it does not meet squarely, point by point, the challenge of the ideological clash of the present day; it does not satisfy the need of the deprived peoples in most of the world. The usual pedantic and half-hearted way in which we have argued the case for democracy leaves the underdeveloped countries cold.

Hungry, illiterate peoples need to be approached with an unambiguous, positive, simple, yet potent statement of a "Creed of Democracy" —a creed they can understand, and through which they can see hope for the satisfaction of their basic needs and the fulfillment of their aspirations. The proclamation of such a creed will also serve as a dynamic support to the progressive elements who genuinely desire the development of economic resources for the welfare of their peoples.

Furthermore, we need such a clear articulation of the principles, achievements, and aims of the democratic way of life for the benefit of the Point Four Program, and the personnel selected to implement it. Technical projects undertaken within, and as part of, the American or Western culture may not need such a pointed ideological orientation. But an entirely different situation arises when Western technology, part and parcel of Western democracy, is put to function within an Oriental way of life. In order to avoid possible conflict with certain aspects and elements of the cooperating culture—and, more important still, in order to avoid the possibility of compromising the basic principles of the democratic message, and thus defeating its purpose—we need to define our terms of reference and take careful stock of our ideological equipment. It is from this ideological background, clearly and consciously articulated, that every technician will be given the necessary orientation and guidance; and it is against this ideological frame of reference that the selection of every aid project will be made, and its success or failure appraised and measured.

The history of human culture, with special concentration in the Middle East, is replete with lessons that are pertinent to our point of emphasis. We find case after case of a way of life developing and flourishing into a major civilization, basically as a result of a central core of values, of beliefs, a consciousness of a message, clearly stated, commonly shared by members of that culture, and vigorously upheld. Then we see that civilization declining and disintegrating when its people begin to lose hold of that binding and dynamic ideological core of their way of life. It ceases to be the personal driving and guiding force of the people.

What happened to the Persians, the Greeks, the Romans, the Arabs, and the Ottomans could happen to the democratic nations of today. Let us not forget that it was only a few years ago that Western democracy almost came to a tragic end under the vigorous challenge and aggressive attack of the Nazi ideology.

It is my conviction that the Technical Aid Program, if broadly conceived, wisely planned, and vigorously and persistently implemented, will make a tremendous contribution to the rejuvenation and growth of Western democracy. It could very well develop into a positive and constructive action program, through which the democratic cultural heritage would reassert itself, strengthen its faith in its basic values, and give them expression on a global scale.

Once more we have to call upon the student of culture and society to assist in this most funda-

mental task. He will select and give expression to those fundamental values that make up the core of the American culture, and of the democratic way of life as a whole; he will interpret them in terms of the other culture participating in the aid program; he will provide the technical expert with the necessary ideological orientation that will give meaning and direction to his technical achievements; and he will indicate where ideological adjustment and compromise will be desirable and fruitful, and where they will begin to be fatal to the program or to either of the participating cultures.

4. The achievement of economic, social, and political stability, and hence the establishment of peace, often have been declared by responsible people to be the major objective of the Technical Aid Program. This is certainly a fundamental objective, the attainment of which is urgent. The world is going through a critical stage of rapidly increasing tension, which may explode into a most destructive global conflict. Any action taken with a view to relieving this tension, provided it is genuine, positive, and realistic, will constitute a contribution to the cause of world peace.

In proclaiming the Point Four Program as a major policy, Western democracy has certainly devised a potent tool for the achievement of stability and the establishment of peace. In intent and principle it is positive and constructive, appealing to the basic needs of the underdeveloped countries. Its effectiveness, however, as an instrument of stability and peace, as a contribution to the cause of democracy, will depend entirely upon how straight we keep our ideological aim, and how thoroughly we can grasp the basic issues that really give rise to tension and instability in underdeveloped countries.

What are these real issues underlying the unstable and potentially explosive situation in most of the Middle East countries? First and foremost is the existence of a tremendous socioeconomic vacuum in their structure. Society there has crystallized into a small minority stratum of the privileged elite on top, a tremendous mass of deprived peasantry and some industrial workers at the bottom, and very little in between. The social and economic distance between the two strata is indeed great. For centuries this type of structure was able to hold together; but it will not be able to do so for much longer.

Outside ideological forces, from the East and from the West, have been at work in this region for many years. A small but growing middle class of enlightened and progressive elements is increasingly making its weight felt in the national scene. Demands for reform are being made, and the rumblings among the deprived masses are growing in volume and intensity. Maintenance of the *status quo* in the Middle East has become an impossibility. That vacuum in its structure will have to be filled in either by bloody revolutions or by peaceful reform. Western democracy has a grand chance to assist in the latter, through the Point Four Program, provided it keeps its aim straight and acts fast.

More specifically, a major factor that is at the root of this state of affairs is the prevailing system of land ownership. Absentee, large-scale owners hold the major portion of the arable land. In most cases their hearts are not in the soil, and they make little, if any, contribution to the management and productive development of agriculture. The majority of the cultivators, who constitute the majority of the population, are landless sharecroppers or wage laborers, who produce just enough to keep alive. They are the victims of illiteracy, disease, and general deprivation. Bitterness and resentment have been increasing among them in recent years. They are seeking a way out of their misery. The only hope they see is to own some of the land they cultivate, or to hold decent tenancy contracts that would guarantee their rights.

There are several other basic problems and issues that need to be studied and solved before stability and peace can be established in the Middle East. Some of these are racial, some are political, and others are religious in character. There is the matter of how people feel toward foreign business enterprise in their country. There is also the problem of tribal settlement, with which several countries of the region are seriously concerned.

What services can the social scientist render the program in this respect? He can use the various techniques at his disposal to discover and clearly define those basic problems and those areas of tension that should be given first consideration. He can probe through these problems and point out the responsible factors. He can go directly to the people and find out with a greater degree of reliability how they feel about this or that ideology, about certain policies and about various problems. He is also qualified to suggest measures that would relieve the tension, and to keep a check on the effectiveness of their application.

5. As specified by the *Act*, the program of technical aid will consist largely of the dispatching of qualified personnel to the cooperating countries in order to assist in their fields of specialization.

Experts in various branches of agriculture, health, industry, water development, and others, will be assigned as individuals or teams to specific field projects. They will apply their technical skill and scientific knowledge to the job directly, and they will also help in the training of local personnel. In either case, they will be in constant touch with the people of the country, functioning within local governmental systems, community organizations, and cultural groupings.

In reality the role of these technicians will not be limited narrowly to the imparting of a skill or an item of knowledge. They will be rather the interpreters of Western culture to the peoples of other cultures. They will be the carriers and implementers of a vital message from Western democracy to the underdeveloped countries. Their success or failure in this task will be of grave consequence.

It would be unrealistic, to say the least, to assume that these experts, because they have done a fine job within their culture, would be able to function smoothly and effectively within a foreign culture. They will be faced there with people who think and act differently, who speak a strange language, who eat peculiar things, who have taboos on certain items and acts, and whose religion, family, and other institutions are different from their Western counterparts. Perhaps above all, our technicians will be struck and frustrated by the apparent lack of respect for time, punctuality, and material achievement. They will be irked by a governmental machinery that does not function as effectively as theirs back home.

In other words, we have to expect a major clash in ideas, attitudes, and actions to arise; and the technical expert will have to bear its brunt. He will have to develop a broad, sympathetic understanding of the other culture, and he will have to learn how and when to make effective adjustment. In order to assist him in this difficult endeavor, the Point Four Program must provide him with adequate training and orientation in the culture of the country to which he will be assigned. I see no substitute for this initial period of training of technical personnel. It must be established as an integral part of the total aid program. It would certainly be shortsighted to argue against it on the basis of the time and expense involved or on the basis that the technician must be dispatched quickly to the field. It would be tantamount to saving pennies and wasting dollars in the long run. At the same time it would not be fair to the technical expert to dispatch him to an alien field thus unprepared.

The social scientist, and the available agencies of social science, are very well qualified to shoulder this responsibility. Many of the leading universities in the United States and in Europe, and a few in the receiving countries themselves, can provide facilities for such training, with relatively small financial assistance. A few of them are already providing excellent service in this respect, although on a limited scale. There are also Federal and private agencies, and some organizations of the United Nations, whose services could be enlisted effectively.

The training and orientation program would acquaint the technical personnel with such basic and pertinent matters as the following: Organization and the central values of the American culture, or of another Western culture, and of the democratic way of life; organization and the basic values of the other cooperating culture; the dynamics of technical and social change; essentials of the language used in the country concerned; the outstanding attitudes and behavior patterns of its people; its institutional and community organization; its class structure and means of communication; conditions of daily living; effective techniques through which a technical project, or its products, could be made readily acceptable to the people; and others.

The following are a few illustrations presented in support of our argument for such a training program:

a. The group of technicians who took charge of an irrigation project in one of the Middle East countries, a few years ago, were well selected, highly qualified in their fields, and conscientious workers. One day, in order to speed up work on the project, they issued dog tags to the several hundred laborers involved. An unexpected rebellion ensued, which threatened to wreck the project. Wearing such tags was to the local people a symbol of subservience, and also was against their religious beliefs. They may have had other reasons, too—perhaps a general suspicion of the motives behind the measure.

b. The American or European head of a technical project established in any orthodox Muslim community will have to adjust his budget, output schedule, his sense of achievement, and his temper to what I describe as the "Ramadan Personality." During the Muslim month of Ramadan people go on a complete fast, from sunrise to sunset. It is a holy month, dedicated to prayer and meditation. The local worker or assistant on such a project develops at this time a personality that is irritable and short-tempered. He expects leniency and understanding for his reduced production. To become

irked and frustrated in the face of such a situation, as many a Western tecnician or expert has done, and denounce local labor as lazy, indolent, and hopeless, will get the head of our project nowhere. He will ultimately reap sullenness and rebellion on the part of the local folk, and estrangement between the two supposedly cooperating cultures.

c. During the years of World War II a group of technical experts was selected and assigned to a developmental project in an isolated area of the Middle East. They were dispatched rapidly to the field, without the benefit of any orientation, at least in the daily living conditions of the locality, to say nothing of the broader aspects of training. Upon arrival, the men realized that they had stepped into a really tough situation. Their first year was mostly one of painful adjustment and agony. They persisted, learned, and gradually got the project under way, but the cost in strain, morale, and money was indeed heavy. Much of this, if not all, could have been avoided through an initial program of orientation.

d. In undertaking its vast field operations in Saudi Arabia, the Arabian-American Oil Company has been wisely sensitive to the significance of local conditions, custom, and traditions. It has endeavored by various means to impress this upon its field employees. Its latest development in this respect has been the establishment of a training center for its personnel going abroad. It is a two-way training program that is doubly rewarding. It involves the assignment of some of its Arabian employees to the center here in the United States, to teach their American colleagues about Saudi Arabia, and at the same time to learn about American life. The company is now convinced that its training program is paying good dividends in the form of better relationships with the local people and less frequent turnover in its American personnel.

6. The services of social science also will be needed in the training of nationals of the underdeveloped countries, who will come here for specialized studies. This is expected to be a major activity of the Point Four Program. Students, technicians, and scientists of various types will be assigned to Federal agencies, universities, or other private organizations, for periods of study and training.

It is equally imperative that these people be subjected to an adequate program of orientation, similar to the one suggested for American personnel. In the first place, the program will assist them in making the necessary adjustments to the American way of life. The smoother the adjustment, the more effective use of the assignment will be. Second, the program will present them with a concise and sharply outlined picture of the basic values in American culture, and in the democratic way of life in general. We are dealing here with a select group of actual or potential technical and professional leaders of their respective countries. It is essential that they take back with them a true picture of what democracy stands for, and how it functions in the daily life of the citizen. This orientation will provide the necessary frame of reference for their observations and studies. Living with the American people will then become more meaningful.

We know enough now, from years of actual experience, to come to the conclusion that a foreign technician on an assignment in this country tends, in the majority of cases, to see and appreciate the great fruits of American industry and agriculture, but not those cultural roots that made such achievements possible. He tends to conclude erroneously that all his country needs to do to emulate the West is to copy from these achievements. This, of course, is not the message the Point Four Program is intended to convey. The best corrective for this tendency is an orientation and training program.

Third, such a training program will provide the foreign technician with a much-needed orientation in his own cultural background, his own way of life. This is not at all a superfluous proposal, as it may at first appear. In many cases, the individual concerned, coming from the Middle East, for example, will be a member of a small privileged minority in his country. His knowledge of the tribal way of life, of the rural community, of the conditions of labor, will be extremely limited. Even if he should come from the midst of these groups, it will not be likely that he will possess a thorough grasp of the essentials of his cultural organization, its trends, and the behavior patterns of its people. His consciousness of these matters needs to be heightened, and his knowledge sharpened. It is only then that he will be able to make his technical training fully meaningful, in terms of his culture and the life of his people.

The Use of Isotopes in Soil Research*

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THE advancement of our knowledge of soils has been closely related to the discovery and application of quantitative methods of measuring the various phenomena that make up the soil complex. Liebig, during the middle of the last century, applied chemical methods to soil problems and opened up a new and valuable period of soil investigations. Microbiological methods have been successfully applied to soil problems, and we are now reaping benefits from these investigations. Significant contributions have been made by the application of physical methods. Much of the information thus gained, however, has of necessity been based on isolated samples of soil in the laboratory. Away from their native surroundings, soils are extremely artificial systems. It is only natural that the soil scientist should be attracted to a method of studying soil problems that would enable him to study soils *in situ*. The isotope method has just barely made its way into the laboratories of the soil chemist, and, as more trained personnel and facilities become available, we can look forward to fundamental increases in our knowledge of the soil.

Stable and Radioactive Tracers

The isotope method is based on the fact that some particular property of the isotope enables the investigator to measure the proportion of that isotope present when it is mixed with other isotopes of the same element. In the case of the stable isotopes, it is the difference in mass that enables one to measure it. The radioactive isotopes are identified by the fact that they emit characteristic radiations of a measurable energy level.

Radioisotopes can be made of nearly all the elements, but some of them are not practical to use because they have an extremely short half-life. The number of stable isotopes available for research purposes is limited by several factors. In the first place a number of the elements have but one stable isotope, so they cannot be used for tracer experiments. Such is the case with fluorine, sodium, phosphorous, manganese, cobalt, arsenic, and iodine. Normal concentrations of a stable isotope should, ideally, be less than a few per cent. The isotope can be greatly enriched, however, thus permitting its detection even when mixed with a considerable amount of the normal element. At the present time, concentration of the larger number of the stable isotopes is carried out by the electromagnetic isotope separation facilities at Oak Ridge. The amounts available are small, but if the need should arise production could probably be increased. Some stable isotopes can be concentrated by chemical exchange methods.

The choice of whether to use the stable isotope or the radioisotope is based on several considerations. Since there is but one stable isotope of fluorine, sodium, phosphorus, manganese, cobalt, arsenic, and iodine, the radioisotopes of these elements must be used. Nitrogen and oxygen have no usable radioisotopes, so the use of the stable isotopes is indicated. The elements carbon, hydrogen, sulphur, and calcium have both radioactive and stable isotopes suitable for tracer work, so other considerations must be studied.

The stable isotopes generally require rather elaborate and specialized equipment for measuring their increased abundance. During the past few years, however, equipment has been simplified, and a number of very satisfactory mass spectrometers are now available. There is no radiation hazard associated with handling the stable isotopes. They can be quantitatively measured, and, in experienced hands, the results are extremely accurate.

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although they are not measurable in as great a dilution as the radioisotopes. In order to measure the concentration of the stable isotope, it is generally necessary to convert it to gas. Deuterium, however, can be measured by means of its specific gravity. In either case the living plants or animals must be killed in order to obtain the sample. With many of the radioisotopes it is possible to follow the isotope in the intact plant or animal over extended periods of time.

A very real problem must be considered when dealing with the radioisotopes. The different types of radiations emitted constitute a health hazard to those handling them. Adequate shielding, short periods of exposure, and cleanliness of both laboratory and personnel minimize these hazards. Laboratories must be constantly monitored to recognize the build-up of dangerous levels of radiation, and satisfactory methods of waste disposal must be furnished. When carrying out field work, adequate safety precautions must be taken. The equipment necessary to measure radioisotopes is, in general, less expensive and less complicated than that used with the stable isotopes. It is capable of detecting and measuring the radioisotopes in extremely great dilutions. When used in carefully planned and executed experiments the radioisotope method is capable of quantitative results. As the novelty of method wears off, increasing numbers of quantitative experiments will be carried out with the radioisotopes. In many types of biological experiments where quantitative results are not needed, the radioisotope method enables one to follow the gross movement of a particular element through a biological system. Radioautographs with X-ray plates also provide a medium for studying the distribution and localization of radioisotopes.

TABLE 1

ISOTOPES THAT MAY BE OF USE IN SOIL INVESTIGATIONS

Element	Isotope	Half-Life
STABLE ISOTOPES		
Hydrogen	H^2 (deuterium)	
Carbon	C^{13}	
Nitrogen	N^{15}	
Oxygen	O^{18}	
Sulfur	S^{33}, S^{34}	
Chlorine	Cl^{37}	
Potassium	K^{40}, K^{41}	
Calcium	Ca^{44}	
Iron	Fe^{57}, Fe^{58}	
Zinc	Zn^{70}	
RADIOISOTOPES		
Hydrogen	H^3	12 years
Carbon	C^{14}	6,000 years
Fluorine	F^{18}	112 minutes
Sodium	Na^{22}	3 years
	Na^{24}	14.8 hours
Phosphorus	P^{32}	14.3 days
Sulfur	S^{35}	87 days
Chlorine	Cl^{36}	106 years
Potassium	K^{42}	12.4 hours
Calcium	Ca^{45}	152 days
Manganese	Mn^{54}	310 days
	Mn^{52}	6.5 days
Iron	Fe^{55}	4 years
	Fe^{59}	47 days
Cobalt	Co^{58}	72 days
	Co^{60}	5.3 years
Zinc	Zn^{65}	250 days
Arsenic	As^{78}	90 days
Molybdenum	Mo^{99}	67 hours
Iodine	I^{131}	8 days

Most of the work that has been done with the isotope-tracer method in soil studies has been carried out with the radioisotopes. A limited amount has been done with the stable isotope of nitrogen. The stable isotopes of sulfur, potassium, calcium, iron, and zinc will make it possible to extend the tracer method to a number of problems in soil chemistry that cannot be approached through the use of the radioisotopes. Table 1 gives a list of the stable and radioisotopes that may be used in studying soils. It is apparent that only a small beginning has been made in applying the isotope technique to soil chemistry problems.

It has generally been assumed that the presence of the tracer isotope does not in any way alter the utilization or metabolism of the element. When using the isotopes of hydrogen, deuterium, or tritium, the differences in mass have been shown to exert a biological effect. In addition tritium is radioactive. In the case of the radioisotopes, however, the effect is not so clear-cut. Many workers have suggested that radioisotopes may bring about serious changes in biological systems. The problem has been studied by a number of workers, and most of them believe that radioisotopes used in "tracer" amounts produce no noticeable effects. Recently some investigators have presented data that show that even "tracer" amounts of radioisotopes may bring about rather striking effects upon growing organisms. The problem is by no means settled, but before extensive biological investigations are started a considerable amount of work must be done to clarify the situation. This is particularly true in soil studies because, in general, it is the response of growing plants that serves as a measure of the efficiency of an isotope applied to the soil. This problem should certainly not prevent the use of the isotope technique, but it deserves careful consideration in planning and interpreting future studies.

Soil Fertility Studies

One of the fundamental problems in agriculture has to do with the maintenance of soil fertility. It

has long been recognized that not all soils are alike in their ability to supply adequate nutrients to crops. Nor are all plants equally efficient in utilizing the nutrients from a single soil. By 1860 plant physiologists had demonstrated, with the aid of solution cultures, that plants required certain elements to grow and reproduce. Carbon, hydrogen, and oxygen were supplied by the atmosphere and water. Phosphorus, potassium, nitrogen, sulfur, calcium, magnesium, and iron were obtained from the soil. During recent years, careful work has revealed that certain other elements may be necessary to insure normal plant growth. Copper, zinc, manganese, molybdenum, and boron have been shown to be essential for a number of different plants.

One of the early concepts of soil fertility considered that a total chemical analysis of a soil, and crop from that soil, would reveal any deficiencies of elements essential for plant growth. A balance sheet was drawn up between the amounts of the elements in the soil and the amounts removed by the crop. The deficiency could be made up by adding fertilizer to the soil. It was soon evident that this simple relationship did not hold. It was very early recognized that certain elements in the soil are unavailable for plant growth.

Attention was next drawn to the soil solution. This seemed to be a logical source of nutrient ions to the plant. A vast amount of effort and ingenuity has been expended in extracting and analyzing soil solutions. Valuable information of a fundamental nature concerning plant nutrition has come from these studies, but the primary problem of measuring soil fertility has not been solved. No general agreement was ever reached regarding a method of extracting the soil solution from a soil. The composition of the soil solution changes from hour to hour, and it is in equilibrium with mineral matter, gases, plant roots, and microorganisms. Furthermore, it is not certain whether the plant roots obtain all the nutrient ions from this solution. Recent work has indicated that plant roots may remove ions from the soil colloid by contact ion-exchange process.

During the years that the chemical studies on soils and soil solutions were being carried out, data regarding the evaluation of soil fertility were being accumulated from other sources. Experiment stations had established fields under different regimes of fertilizer treatment and cropping practices and had been gathering yield data. Probably at least a thousand well-recognized soil types are utilized for crop production throughout the country. On most of these soils a variety of crops is grown, so that the amount of work necessary to characterize these soils as to their soil fertility levels by field tests is truly staggering. A number of chemical "quick-tests" have been devised for measuring the levels of nitrogen, phosphorus, potassium, and other nutrients in soils. Where it has been possible to calibrate these tests in terms of yield data gathered from years of experiment station records, they have proved useful for predicting and diagnosing the fertility needs of soils.

During all the years of measuring crop response to added fertilizers, there was no way of telling how much of the added nutrient was utilized by the plant. The fertilizer could not be differentiated from the elements native in the soil. A method had been devised by Hevesy in 1923 for studying the uptake and translocation of radiolead in plants. Plants were grown in a solution containing thorium B (Pb^{212}), a natural radioisotope of lead. At various intervals plants were removed from the solution and analyzed for radioactivity. Plants that contained radiolead were transferred to solutions containing inactive lead salts, and it was found that the radiolead appeared in the solution. The method was limited to the naturally radioactive elements, and these were of limited value in soil and plant studies. With the discovery of artificial radioactivity by Joliet and Curie in 1934, the method became applicable to a large number of elements. The radioisotope technique as described by Hevesy in 1923 is followed in essential detail in present studies.

Radiophosphorus

One of the first radioisotopes available for soil research was radiophosphorus (P^{32}). P^{32} can be produced by a number of nuclear reactions but can best be made in quantity in the nuclear reactor. Most of the work done in this country with P^{32} has been carried out by scientists of the U. S. Department of Agriculture. In collaboration with a number of state experiment stations, they initiated several years ago an extensive investigation of phosphorus fertility. Most of the work reported in this section has been gathered from several progress reports published by these collaborators.[1, 2, 3]

Phosphate fertilizers were placed on the market about a hundred years ago, and since that time soil scientists have expended considerable effort in trying to ascertain the place of phosphorus in our agricultural economy. The phosphorus content of most soils is naturally low, and the amount available to plants at any given instant is exceedingly small. Under a number of conditions, applied phosphates are rapidly tied up by the soil and become unavailable to plants. Since large sums of money

are spent annually by farmers on phosphatic fertilizers, it is of considerable importance to know how much fertilizer phosphorus a plant utilizes as opposed to soil or native phosphorus. The availability of P^{32} makes possible for the first time a critical evaluation of the role of phosphorus in soils and plants.

There are a number of considerations that make P^{32} a very valuable isotope. It can be made carrier-free, which means that when used in an experiment rather large dilutions can be made and the P^{32} will still be measurable. The isotope disintegrates and emits a negative β-particle that can be detected by a number of commercially available instruments. It has a half-life of 14.3 days, which indicates that it can be used for an entire growing season.

The radioisotope technique as applied to soil investigations is relatively simple. A phosphatic fertilizer is made up to contain a definite amount of radiophosphorus per unit amount of phosphate. This material is then applied to a soil upon which a crop is to be grown. The plants are analyzed at various times for their total phosphorus content and radiophosphorus content. If the radiophosphorus content of the plant per unit amount of phosphate is half that applied as a fertilizer, then the plant derived half its phosphorus from the fertilizer. By this procedure one is able to investigate the effectiveness of various phosphatic fertilizers, the influence of different methods of fertilizer placement, the effect of native phosphate on the uptake of fertilizers, and the influence of plant species on the utilization of phosphorus.

Because of the radiation hazards involved in preparing and handling fertilizers containing radiophosphorus, the scientists of the USDA have played a major role in developing the technique and methods necessary for these fertilizer studies. They have been able to develop satisfactory methods of preparing and applying the fertilizers. They have also been responsible for measuring the P^{32} content of the plants grown on the experimental fields. As more research workers become familiar with the isotope technique and as more laboratories equipped for handling isotopes become available, a broader program of soil investigations will be undertaken by the state experiment stations.

One of the first studies undertaken with P^{32} was relative to the efficiency of various phosphatic fertilizers. Superphosphate and hydroxyapatite were made up containing P^{32}. Preliminary studies on three different soils were carried out in the greenhouse. These soils had been shown by chemical methods to vary considerably in their available phosphorus content. The fertilizers were thoroughly mixed with the soils in pots, which were then seeded to perennial rye grass. Cuttings were taken at various times, and the plants analyzed for P^{32} and total phosphorus. It was found that the superphosphate was more readily used by the plants than was the hydroxyapatite. More striking, however, was the demonstration that the utilization of fertilizer phosphorus was inversely proportional to the phosphorus fertility level of the soil. The plants took up more of the applied fertilizer from the soil type that was low in available phosphorus than from the soil high in the element. The total amount of phosphorus in the plants was directly related to the amount of phosphorus available in the soil. These observations have held up in subsequent field tests with a number of different crops on a variety of soil types.

Subsequently the USDA group has made up P^{32}-labeled ammoniated superphosphate, diacalcium phosphate, α-tricalcium phosphate, and calcium metaphosphate. These represent types of phosphatic fertilizers that are commercially important in agricultural practice. These materials have been field tested in experiment stations in Colorado, New York, Iowa, North Carolina, and Illinois. Such crops as corn, tobacco, sugar beets, oats, potatoes, cotton, pasture grasses, wheat, barley, soybeans, and alfalfa were grown on various soil types using the P^{32}-labeled fertilizers. The greatest uptake of fertilizer phosphorus occurred in soils low in available phosphorus. Superphosphate appeared to be the most readily utilized phosphorus source. This varied from location to location and by crops but was noted by most of the investigators. As these studies are extended to different soils and crops under a wide variety of climatic factors we can expect a rather complete picture of the efficiency of utilization of the various phosphatic fertilizers.

Another problem of interest regarding phosphorus fertilizer is concerned with the effectiveness of different methods of application. This is closely related to the type of plant that is to be fertilized. A plant having a shallow fibrous root system will differ in its ability to take up soil nutrients from one that has a deep taproot system. P^{32}-labeled fertilizer enables the investigator to study these problems for the first time.

The question of how much fertilizer to apply to crops is of tremendous agronomic importance. Field studies were made on corn, tobacco, cotton, and potatoes with two different rates of applications of phosphorus fertilizer. The cotton, tobacco, and potatoes had considerably greater con-

centrations of fertilizer phosphorus when treated with high rates of fertilizer application. The corn crop gave only a small increase to the high rate of application. More work on this problem is under way.

It has been long recognized that different plants vary in their phosphorus requirements. Not only do they utilize different amounts of phosphorus, but their requirements vary at different stages of growth. Using P^{32} it has been shown that potatoes are heavy feeders on phosphorus and are dependent upon large amounts of readily available phosphorus throughout the growing season. Corn and soybeans were shown to be dependent upon fertilizer phosphorus during their early growth but were able to utilize soil phosphorus more efficiently during the late stage of growth. This is probably related to the nature of the root system of these crops. The corn roots are rather shallow but quite extensive and are able to draw upon a rather large volume of soil for nutrients. Soybeans have been shown to behave similarly. With tobacco it has been shown that in the seedling stage the plants are heavy feeders on applied phosphorus but are less dependent during their later growth.

In many parts of the country where livestock play a prominent part in the agricultural picture, farm manures are an important source of phosphorus. Manure labeled with P^{32} was prepared by workers at Cornell University and added to soil which was seeded with rye grass. The plants were able to derive as much phosphorus from the manure as from superphosphate. The use of green manures was investigated by the USDA, and it was found that green manure phosphate was approximately 70 per cent as efficient as superphosphate phosphorus. The role of soil microorganisms in causing organic residue to decompose and liberate elements that are then available for plant growth remains to be investigated. The isotope technique will greatly facilitate these studies.

One of the most fundamental problems concerning phosphorus fertility is what happens to phosphorus when applied to the soil. It has long been known that under certain conditions of soil pH, applied phosphorus becomes unavailable to plants. At an acid pH the phosphorus is tied up in insoluble forms with iron, aluminum, or manganese. At alkaline pHs the phosphorus reverts to insoluble forms, which are also relatively unavailable to plants. It has been suggested that at a pH range of 5.6–6.5 phosphorus exists in its most available form. In this pH range the phosphate ions in solution may be in equilibrium with phosphate ions on the surface of soil colloidal particles. The nature of the exchange reactions has been investigated with radiophosphorus. A sample of soil was shaken with water for a period of time to establish an equilibrium between the solution phosphorus and the phosphorus attached to the colloidal surfaces. The phosphorus content of the solution was then measured, and a small amount of radiophosphorus was added to the soil-liquid mixture. The amount of P^{32} was not great enough to disturb the equilibrium between the solution phosphorus and colloidally attached phosphorus. At frequent intervals samples of the solution were removed and analyzed for total phosphorus and radiophosphorus. It was found that two separate reactions could be detected that indicated an exchange reaction between the soil-solution phosphorus and the soil-attached phosphorus. The first reaction was considered as a measurement of the readily exchanged phosphorus of the soil, whereas the second reaction may indicate more stable and therefore less available phosphorus.

Fertilizer phosphorus may be made unavailable to plants by means of a chemical reaction with the soil colloidal particles. The hydroxy ions of the colloid may exchange with phosphate ions from the solution. The nature and extent of the exchangeable hydroxylic surfaces of several soil minerals were studied by substituting deuterium for the hydrogen of the hydroxy ions. The studies showed that there were substantial numbers of hydroxylic surfaces available for exchange reactions on some of the common types of soil minerals.

Nitrogen

Nitrogen is probably the most important fertilizer element in agricultural use. There is no satisfactory radioisotope of nitrogen available, but there is an excellent stable isotope (N^{15}). Because of the rather elaborate equipment needed to assay the stable isotopes, very little work has been done to date with N^{15}. As a number of experiment stations have recently acquired the necessary equipment for measuring stable isotopes, considerable work can be expected in the future. Soils derive nitrogen from crop residues, green manures, farm manures, fertilizers, and nitrate and ammonium salts added through rainfall. Atmospheric nitrogen is fixed by soil microorganisms. Nitrogen is lost from the soil by crops, drainage, and in the gaseous condition. These various factors have been tied together in a nitrogen cycle, and the interrelationships offer an attractive field of research with N^{15}. Some work has been done with the problem of the fixation of atmospheric nitrogen using N^{15}. It has been shown that biological nitrogen fixation is

limited to leguminous plants, plus root nodule bacteria, several bacteria, and a blue-green alga. N^{15} has been used to verify the idea that nitrogen fixation takes place in the root nodules of leguminous plants.

Potassium

Both a stable and a radioisotope of potassium are available for research purposes. The radiopotassium (K^{42}) has a short half-life of only 12.4 hours and is thus not usable for long-term field studies. Some work has been carried out with K^{42} in plant nutrition, but for field work it will be necessary to use the stable isotope (K^{41}). The amount of K^{41} available for research purposes is rather small, and for the time being only a limited amount of work can be done. There are many problems of interest to the soil scientist that are tied up with soil potassium. Soils that have been under intensive cultivation for some time are generally deficient in potassium. Applied potassium is found to be readily leached from soils, since it does not appear to be bound firmly to the soil surfaces, as is phosphorus. Plants are known to differ in their need for potassium. Tobacco and potatoes, for example, are considered as exceptionally heavy feeders of potash. The role of potassium in the plant has not been satisfactorily worked out; with a combination of the stable isotope and the radioisotope it is hoped that these and other problems can be solved.

Calcium

Calcium plays a very substantial role in the agricultural economy of our nation. The practice of liming has been carried out for many years. It was thought originally that the primary role of lime was to influence and modify the pH of the soil. More recently the importance of the calcium ion itself has become recognized. Many physical properties of the soil depend on the presence of calcium ions. The highly fertile "black" soils of Kentucky, Alabama, Texas, and the corn belt states are high in calcium. The calcium is important in maintaining a high level of soil organic matter. Calcium can be applied to the soil in a variety of forms, but there is no general agreement as to the most satisfactory form. Limestone has generally been used, and it is known that the degree of fineness of the limestone influences its availability in the soil. Sweet clover, alfalfa, and red clover respond to application of lime, but lespedeza, cowpeas, and vetch do not appear to benefit from it. Of the nonlegumes, asparagus, spinach, beets, and cabbage are strongly influenced by lime, but corn, oats, and sorghum show little response. Only a few problems have been mentioned, but it is apparent that much work needs to be done in working out the soil calcium relation. There is a radioisotope of calcium (Ca^{45}) available, but it has a half-life of 152 days. Such an isotope when applied to the soil will remain radioactive for several years. Work with the calcium isotope will be limited to groups who have special facilities for handling long-lived isotopes that emit low-energy particles. The new U. S. Department of Agriculture laboratory at Beltsville, Maryland, has announced initiation of a study with radiocalcium. Cornell and Tennessee have also started programs with Ca^{45}, but no results have yet been reported. Calcium 44 is a stable isotope that might be used where Ca^{45} would not be applicable, but it is available at present only under special conditions from the Atomic Energy Commission.

Sulfur

Sulfur is not ordinarily considered to be a limiting factor in crop production. In some areas, however, it is necessary to add sulfur to insure adequate alfalfa crops. Under most conditions of crop rotation and fertilizer applications, sufficient sulfur is added to the soil to obtain crop growth. Sulfur is also added to the soil in rain water, and it has been shown that higher plants can absorb sulfur dioxide from the atmosphere. Several studies have been carried out with the radiosulphur isotope S^{35}.[4] This isotope has a half-life of 87 days and is very well suited for experiments that must last several growing seasons. Plants were permitted to take up S^{35} in the form of sulfate ions or in the gaseous condition from S^{35}-labeled sulfur dioxide. The sulfur in the plant was then separated into several fractions. Corn, tomatoes, and sugar beets were found to utilize both forms of applied sulfur. A stable isotope of sulfur is also available for supplementing the work with radiosulfur in investigating the role of sulfur in the soil.

Other Elements

Of the other elements essential for plant growth —magnesium, iron, copper, zinc, boron, and manganese—there are satisfactory isotopes available with the exception of magnesium and boron. Comar[5] has discussed the problems involved in the use of radioisotopes in nutritional trace-element studies. There have been adequate analytical methods for analyzing plant or animal tissue for many of the chemical elements, but the amount of

the "trace" elements present in normal tissue is generally below the level that can be accurately determined by conventional chemical methods. Improved analytical methods have given to the investigator a means of determining the concentrations of the "trace" elements in soils, plants, and animals. These methods, spectrography and spectrophotometry, when used in connection with the radioisotopes, will enable one to follow the metabolic fate of the "trace" elements in biological material.

Weed Killers and Insecticides

The use of weed killers and insecticides has increased enormously during recent years. The increased yields attributed to these materials have been as great as, or greater than, the yields attributed to the application of fertilizers. It is known that some of the weed killers have a residual effect in the soil. A similar situation has been suggested with regard to some of the insecticides. The use of isotopically labeled insecticides and weed killers in the study of this problem should be invaluable in showing the nature and extent to which these materials are fixed in the soil and how they affect plants growing in the soil. Carbon 14, chlorine 36, and sodium 22 may be useful in such investigations.

Since the time when natural radioactivity was discovered in some of the elements, it has been suggested that plant growth might be affected by radioactive materials. Some truly fantastic claims have been made from the bombed areas in Japan about enormous increases in yields in plants growing in the affected area. Other reports have appeared from different areas claiming increased yields of plants as a result of the application of radioactive materials to the soil. Several years ago the Atomic Energy Commission made a special grant to the Bureau of Plant Industry, USDA, to carefully study the problem. Experiments were set up to cover a wide range of crops and soils, as well as different rates of application of the radioactive materials. A commercially available product and radium were tested. The experiments have not been completed, but the results to date do not show any stimulation in plant growth due to the application of the radioactive materials.

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SCIENCE ON THE MARCH

OKLAHOMA STUDIES ON EVAPORATION DATA

SEVERAL government agencies—the Geological Survey, the Bureau of Reclamation, the Navy, and the Weather Bureau—are using novel methods of winning meaningful data from Lake Hefner, near Oklahoma City, with which to solve an old hydrologic mystery—the amount of water lost by reservoirs through evaporation to the atmosphere.

When a stream is dammed to provide water for irrigation, power generation, and flood control, as in the American Southwest, the fact that every time more acreage of water surface is exposed, more and more precious gallons per day are licked up by the atmosphere becomes of high importance. It could mean that adding one more dam to a well-developed river basin might extend evaporating surfaces beyond the point where there is a compensating gain in water storage, and might actually result in a subtraction from the usable water supply for the regional project as a whole. In such an event the building of that dam would be a waste of money, effort, and natural resources. In balancing water storage capacity the trick is to pay proper regard to over-all economic results.

One difficulty lies in the fact that no one knows just how much moisture the atmosphere demands from a given expanse of water under varying climatic conditions. The present method of determining this is by setting out four-foot evaporation pans, the loss of water from which can be easily measured. Such pans are of proved value to weather experts as a measure of atmospheric conditions, but what relationship these pan losses bear to evaporation losses over large bodies such as Lake Mead is undetermined.

A search through scientific literature indicates several avenues of approach to the problem, but not until such knowledge was considered of importance to determine how long Lake Mead would be useful as a reservoir (with quantities of silt being dumped behind Hoover Dam each year) did scientists band together to seek a real solution. No single scientific approach could possibly yield conclusive results. For this reason the U. S. Geological Survey, one of the government's key fact-finding agencies, was asked by the Bureau of Reclamation to review the whole problem of water losses in reservoirs, particularly those losses resulting from evaporation, and to lay out a program for evaporation investigations particularly applicable to water losses at Lake Mead.

On the basis of present methods of calculating evaporation, the annual loss from Lake Mead has been estimated at about 800,000 acre-feet, or more than 25 trillion gallons. C. P. Vetter, chief of the Office of River Control for Reclamation at Boulder City, Nevada, figured the total losses from present and proposed reservoirs in the Colorado River basin, together with channel losses in the lower part of the basin, might exceed 2,000,000 acre-feet per year.

This much water could irrigate more than 400,000 acres or, if used for the generation of hydroelectric power, would provide almost 2 billion kilowatt hours, enough to take care of the needs of a community like Oklahoma City for upwards of two years.

Such figures as these drive home the need for precise knowledge of evaporation rates. For both the operation and planning of future reclamation projects, it is obvious that evaporation facts are needed. How to obtain such facts was the next problem. To conduct the studies initially at Lake Mead was out of the question. There were too many variables that could not be controlled there.

At present there are four means of determining evaporation. In the first method, known as the "water budget," evaporation is determined by measuring inflow, outflow, and changes in storage. This method is not generally practicable because the evaporation is often small compared to errors in measuring the inflow and outflow, and because seepage and bank storage are uncertain and changing factors.

The second method utilizes "evaporation pans." Considerable work has been done by various investigators on the relation between evaporation from a pan of a certain type and evaporation from a lake or reservoir. This method is in use at present, but has been widely criticized because the "pan coefficients," determined experimentally for various pans, apply only for the conditions under which they were determined.

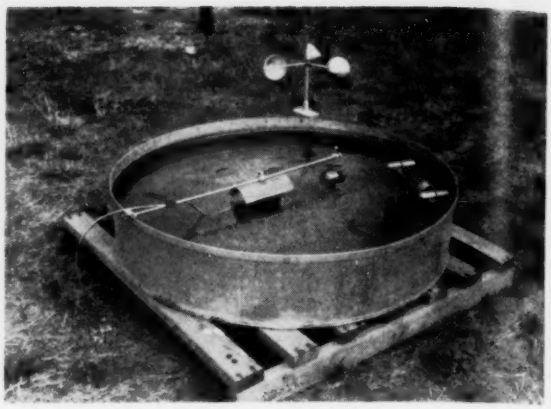
The third and fourth methods result from recent developments in oceanographic and meteorologic theory and have not been adequately tested in practice. The third method is known as the "energy budget" and is based on a determination of

the energy available for evaporation. In the fourth method, derived from modern "mass-transfer theory," certain factors affecting the transport of water vapor are measured and the evaporation calculated therefrom. The Oklahoma City studies will explore these last two methods, using the water-budget method as a control. They will also enable the Weather Bureau to relate evaporation pan data to evaporation from Lake Hefner, thereby improving evaporation pan data throughout the United States.

What was needed as a scientific control was a reservoir like a saucer, several miles in diameter, with a bottom that doesn't leak; where literally every drop of water in it could be accurately measured, together with the amount going in and drawn out. The difference between inflow and outflow, allowing for any change in the amount of water in the saucer, would be the quantity lost to the atmosphere.

The Geological Survey and the Bureau of Reclamation canvassed their field offices in search of such a lake. After considering more than one hundred throughout the West, Oklahoma City's Lake Hefner was found to come about as close to providing a natural outdoor laboratory as could be expected. Lake Hefner is a saucer approximately two and one-half miles in diameter, scooped out at the very headwaters of a drainage basin.

Shown here are two types of evaporation pans now used to determine evaporation rate on large bodies of water.



Standard Weather Bureau evaporation pan (shown here with a whirling cup anemometer to measure the speed of any wind passing over the water surface, together with apparatus for keeping track of the water temperature) has long been the established method of determining rate of evaporation from large bodies of water.

Through a dike, or dam, almost four miles long, very little water is lost, and even this can be accurately measured. The bottom, of compacted red clay, is nearly impervious to water leakage.

Last winter Bureau of Reclamation engineers calibrated the venturi meter at the filtration plant that measures the amount of water drawn from the lake to supply Oklahoma City. This meter is considered accurate to within 1 per cent. Rain gauges have been set up at twenty-three points on and around the lake to measure the amount of rainfall. Multiplying this figure by the total lake surface will give the amount of water added directly through precipitation. As a further check on the drainage basin, weirs and recording gauges have been installed near the mouths of the two inlet streams. Because there are almost no trees on the reservoir rim, losses by transpiration can be practically disregarded.

Here, then, is the almost perfect "saucer," with an almost unobstructed expanse of water. In fact, it is very much like the evaporation pans in which Weather Bureau scientists place a known amount of water and then measure the rate at which this disappears under the influence of solar radiation and wind. But scientists have long suspected that there is a big difference between the evaporation rate from a shallow pan and from a reservoir, lake, or the ocean, so that one cannot merely compare relative surface areas and come up with an accurate figure. Factors like depth of the water, its temperature, the amount of heat it absorbs, and, above all, the difference in scale between a pan and a large body of water with quite different wind effects, must also be taken into consideration.

Although present pan measurements may not

be a direct measure of what the evaporation rate will be on a large body of water, yet, as proposed by the Weather Bureau, perhaps a definite correlation can be derived that will give them more meaning. This will immediately make the vast store of evaporation data of the Weather Bureau more useful in the planning, design, and operation of projects.

That Oklahoma City doesn't depend upon local rains to fill Lake Hefner is a unique feature that made this site so outstanding. Each time the North Canadian River, which flows near by, reaches flood stage, city experts on the chemistry of water keep a watchful eye on the muddy color of the river and measure its mineral and salt content. When conditions are optimum and the waters sufficiently dilute, a special diversion canal is opened and Lake Hefner is filled from the river. This takes five or six days and raises the lake level by six or eight feet.

Keeping track of the water additions and losses will be the work of Geological Survey's Water Resources Division, under the supervision of G. Earl Harbeck. This will be accomplished on a daily as well as a weekly basis. Survey engineers will be responsible for the preparation of an accurate area-capacity curve for the lake, based on a hydrographic survey made with echo-sounding equipment. The Air Force has flown a pattern over the lake area and turned out needed air photographs to supplement old and new maps. Such mapping operations are also needed to plot the drainage area and to determine accurately the water runoff figures after each storm.

Computing the "water balance" involves straightforward techniques that can be readily applied by Geological Survey hydrologists. But the other aspects of the problem are more complex. In Lake Mead and other large reservoirs it will not be possible to determine evaporation by the water-budget method; hence, the aim of these studies is to develop an improved method or methods for determination and, if possible, the prediction from weather data of water losses by evaporation, using mass-transfer and energy-budget theory.

A clearer understanding of evaporation would also be of use (1) in determining the effects of meteorological conditions on electromagnetic and sound propagation in the lower atmosphere, and (2) in the solution of oceanographic-meteorologic relationships.

Thus one attack is to strike an "energy balance," or to determine the "heat budget" of Lake Hefner. An accurate account will be kept of all radiation from the sun in the course of a year, against which will be charged reflected radiation and heat absorbed by the water. The rest must be what is used up in evaporation processes. Another attack will consist of evaluating a series of equations concerned with the physical removal of water to the atmosphere. Evaporation follows definite physical laws and is affected by such things as air and water temperature, amount of moisture already in the air, wind velocity, and height of waves kicked up, as well as by the amount of solar energy that falls directly on the lake surface. All these factors can and will be measured and will enter into the final computations.

Frank Kennon, Geological Survey's resident engineer, shown making a periodic inspection to insure that the Survey's apparatus for measuring stream flow at one of Lake Hefner's intake points is in proper working order.

Here, again, as in the recent Lake Mead siltation studies, the Navy Bureau of Ships, and the Navy Electronics Laboratory (NEL) were called upon for help. The Lake Mead "Navy" has been moved to Oklahoma. It includes one naval lieutenant, two chief petty officers, and such technical equipment as boats, anemometers, rain gauges, and towers. For more than a year NEL had been developing the instrumentation necessary to gather data with which to study the mass-transfer and energy-budget methods of calculating evaporation. Because the U. S. Weather Bureau has been active for many decades in recording what happens to water left exposed in pans, that agency was also asked to participate.

As its part of the program, Weather Bureau technicians have installed several types of evaporation pans, complete with anemometers, and water and air thermometers, as well as twenty rain gauges and other meteorological equipment. They are also making the daily climatological summary from the Oklahoma City Weather Station immediately available for use in connection with the study. They will study these data in relation to

corresponding observations on the lake and compare their evaporation figures with the water budget, to devise sounder and more reliable methods of using pan evaporation data. This will be a notable contribution to this cooperative study.

Navy Electronics Laboratory researchers under Dana Russell have assumed responsibility for the meteorological observations, the thermal survey, and for analysis of the data. Their studies to date have been summarized in a recently issued report, *A Review of Evaporation Theory and Development of Instrumentation*, by E. R. Anderson, L. J. Anderson, and J. J. Marciano, all of NEL.

The observations at Lake Hefner, made at the rate of one every thirty minutes for thirteen months, will be recorded on punched cards and will furnish information valuable not only for these immediate studies, but for scientists who may have need of it in the future. When all the records are in, it is expected there will be more than 80,000 cards involved. High-speed analysis and computation machinery will be used to make the results immediately available. NEL is also furnishing special electronic instruments designed for these studies, now operating at the main data-collection points. Navy and Survey personnel have been at work establishing the four data collection points—three on land and one in midlake—during the past six months.

Established in the middle of Lake Hefner near Oklaoma City is this cross-shaped barge built of thirteen Navy pontoons joined together to form a base of operations from which scientists can collect data on the rate at which water is evaporated from large lakes and reservoirs. Mast and barge are alive with whirling anemometers, hat-shaped apparatus for measuring air temperature and humidity using thermocouples, pyroheliometers for measuring solar radiation, and recording apparatus, including an ingenious amplifier that is a combination of electronic devices.

Chief interest, however, centers around the station established in midlake, where thirteen Navy pontoons were joined together to form a single barge. This is anchored by eight drags fashioned out of barrels loaded with cement and spiked with short sections of steel rails and I-beams. Each of these stations seems alive with whirling cup anemometers to determine wind velocities at different elevations above the water, especially designed "hats" containing thermocouples to measure temperature and humidity, and a vane to note wind direction.

In addition to air temperature and humidity, the temperature of the lake surface will be recorded at each station. For this purpose a thermocouple will be held just below the water surface by a special float anchored well away from shore. A length of the thermocouple cable used on the air-temperature elements connects the couple to the recorder.

The recording apparatus, particularly the amplifier, is an ingenious combination of electronic devices. Without this the whole program of evaporation studies might have had to be scrapped. Success in the studies depends upon a continuous automatic record of observations over an entire year; and because the only power available is that supplied by batteries, a method had to be developed for amplifying the tiny electric voltages coming from the various instruments, so that a visible record could be kept. Ordinarily this calls for a sizable amount of power, but under the newly developed system each of the small voltages is amplified separately.

General responsibility for the studies at Lake Hefner rests with William E. Wrather, director of the Geological Survey. Cost involved is in the neighborhood of $90,000. Carl G. Paulsen, chief hydraulic engineer, will represent the director in the over-all operation. Collaborating with him are the chiefs of the Geologic and Topographic Divisions. George B. Cummings, electronics engi-

Top of mast above barge on Lake Hefner showing arrangement of cup anemometers for measuring wind speed, hat-shaped apparatus for measuring humidities, and at the top a globe-shaped pyroheliometer for measuring amount of radiation reflected upward from the lake. These instruments and others are all connected with recording apparatus in a closed compartment below.

neer in the Sonar Systems Branch of the Bureau of Ships, will represent the chief of that bureau, and Morgan D. Dubrow, Hydrology Liaison for the Bureau of Reclamation, will represent that agency.

At Lake Hefner throughout the year, to service the stations and take care of special needs, will be Frank W. Kennon, resident engineer, Lt. C. C. McCall, USN, and Navy Chief Petty Officers Joseph D. Freitas and Harold E. Knudsen. Local offices of the Geological Survey, the Bureau of Reclamation, and the Weather Bureau are also cooperating in the study, as is the Water Department of Oklahoma City.

Navy Electronics has developed the necessary special instrumentation, reviewed evaporation literature, and will test the energy-budget equation and all existing mass-transfer equations that seem to have merit. They will use the Survey's water budget as a control, to determine experimentally which of existing equations gives the best results. If no present theory gives consistent answers, they will then modify existing theory or develop a new approach.

Thus upon NEL falls the final task of recommending to the cooperating agencies a method or methods for determining water losses by evaporation from any lake or reservoir—and, if possible, presenting a method for predicting mean evaporation losses from available climatological data.

The investigation is nearing the halfway mark. Field work is proceeding in orderly fashion and, except for a wet period this summer, there have been no disturbing factors. Preliminary indications are that data being obtained will be usable for the intended purpose.

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BOOK REVIEWS

ECOLOGY AS SOCIOLOGY

Human Ecology. Amos H. Hawley, xvi + 456 pp. Illus. $5.00. Ronald Press, New York. 1950.

CALLING a game of one-o'-cat baseball would not establish it as such in the eyes of devotees of the national sport; neither will Dr. Hawley's declaration of his own ground rules satisfy many ecologists. His game still looks like sociology, in spite of the new label.

The holistic view of ecology is rejected on the curious ground (p. 10) that "it is apt to encourage hasty generalization and immature synthesis." Good science would seem to be unacceptable because of bad scientists, which is throwing out the baby with the bath water, with a vengeance! In place of "the interrelation between living organisms and their environment, including both the physical and the biotic environments, and emphasizing interspecies as well as intraspecies relations" (Allee, Emerson Park, Park and Schmidt: *Principles of Animal Ecology*, Saunders, Philadelphia, 1949), Hawley treats human ecology as (p. 73) "primarily a sociological concern [that] deals with the central problem of sociology, that is, the development and organization of the community." Furthermore (p. 179): "Human ecology studies the structure of organized activity without respect to the motivations or attitudes of the acting agents." Autecology is specifically excluded (p. 67), since to consider it "would appear to be an unwarranted invasion of the fields of physiology and psychology. . . ." Thus we have an "ecology" that largely disregards man's biophysical environment and his interactions with it; his genetics, so profoundly influenced by his organized activity; and the characteristic that above all others differentiates him from other animals: the operation of his mind. We are left with the relationship of a fraction of an organism to a part of its environment. In a world of interdependence (which Dr. Hawley stresses) where most elements function as dependent variables, this eco-lobotomy inevitably produces something like a zombie.

The author's touchstone, technology, is viable, of course, only in the absence of such limiting factors as unavailability of resources upon and with which it can operate; social obstacles such as war and exploitation by inhuman and corrupt governments and other groups; and a high population potential in overcrowded areas, especially when this is coupled with impossible socio-economic aspirations—i.e., motivations and attitudes. Disregard of such forces operating in total situations makes meaningless statements like (p. 161): "In no instance, however, are such conditions [famine and malnutrition] due to exhaustion of resources, climatic events, or even an actual lack of food." Such a statement might be true in the neo-Rousseauvian world where ideal economics has replaced the noble primitive, but it would have been hard to sell it to a Ukrainian peasant in 1933, a Norwegian in 1943, or a Chinese or Haitian in 1950!

Hawley's formulation inescapably produces a map that will mislead the uninformed traveler through the territory it is intended to describe; a map that, by definition, leaves out relief and watercourses will not be of much help in winning campaigns.

It is difficult to tell whether many assumptions scattered through the book are the cause or the effect of the author's formulation; they are probably both. For example, he tells us (p. 16): individuals are "striving not only to live but to live better and more abundantly;" this statement might be questioned both by psychiatrists and by cultural anthropologists. And what would be the meaning of "better and more abundantly" in the case of such influential individuals as Hitler, Stalin, Gomez, Hearst, the Aga Khan, and the Soong family? "Along with the emergence of an extensive territorial division of labor," he writes (p. 161), "has gone a growing abundance of resources." This scarcely jibes with the recent presidential address of Sir Harold Hartley, before the British Association for the Advancemen of Science, in which he said: "Estimated reserves of copper, zinc, lead and tin are adequate only for some decades, and if all the world used them at the same rate as the United States, there might be shortages within ten years."

The channelized vision that Hawley has brought to bear on this problem, excluding so much of space-time beyond his narrow periphery, throws into jeopardy the considerable amount of excellent sociological material his book includes; it would be a confusing, even a dangerous, book to give an undergraduate who was without the criteria with which to evaluate it, or the intellectual curiosity to measure it against such works as the *Principles of Animal Ecology* mentioned above, and Alfred Korzybski's *Science and Sanity*.

In a world of global confusions, where individuals really striving toward a better and more abundant life are wandering like lost Boy Scouts because their maps do not fit the territory of reality, there is an urgent need for adequate discussions of human ecology. Perhaps, as Hawley suggests (p. 10), "it is beyond the capacity of any one individual to explore the entire field."

It is to be hoped that future authors, no matter how bemused they may be by the man's technological ingenuity, will bear in mind the words of Sir Arthur Keith: "In the clash and turmoil of this modern world we are hearing the creaking wheels of the machinery of evolution."

WILLIAM VOGT

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ANT TAXONOMY

The Ants of North America. William Steel Creighton. 585 pp. + 57 plates. $10.00, paper. Cosmos Press, Cambridge, Mass.

STUDENTS of ants will welcome this publication, the most comprehensive and thorough taxonomic treatment of our fauna in the history of North American formicology. Although primarily a taxonomic treatise, the book also contains a great deal of valuable information pertaining to the biology and distribution of our ants. The author has made a serious effort to eliminate invalid forms, thereby reducing the total number of previously known forms from 742 to 585. One accustomed to established names will find many radical changes. No varieties are recognized, these having been either synonymized or elevated to higher rank. Subspecies are likewise occasionally synonymized or else elevated to higher rank, and species synonymized. In considerable detail the author explains his reasons for synonymizing certain forms. In most instances his acts seem justifiable, but occasionally it would appear that his decisions rest largely on hypothesis.

Written in a very lucid and forceful manner, the book contains unusually interesting information under such headings as the Present Status of Ant Taxonomy and Nomenclature and the History of Ant Taxonomy in North America. Good keys are furnished for the identification of workers and females, from subfamilies to subspecies. A habitus picture is presented for one species in each genus by outline drawings of a worker, female, and male, when all castes are known. Usually a wing is also shown. General remarks on taxonomy and biology may be found under the headings for the various groups, species, and subspecies, as the case may be. Under each specific and subspecific heading are given a citation to the original article in which the form was described, synonyms, references to helpful illustrations and taxonomic articles, type locality, place where the type was deposited, and the general range of the form.

It is unfortunate that the cost of the publication prevented the author from furnishing supplementary characters for distinguishing the forms other than those given in the keys. The cataloguer will especially be disappointed to find that new synonymy is not indicated. The distributional ranges of the various forms are often misleading or incorrect; for example, the author states that *Atta texana,* one of our common and important economic species, is not recorded from Louisiana, although it might be expected to occur there. Actually thirteen Louisiana parishes are infested, and the Southern Forest Experiment Station at New Orleans has been conducting control experiments on the species for a number of years! It is especially regrettable that the higher groups are not included in one common index with those of the species and subspecies. Plates are consecutively arranged in the back of the publication in proper taxonomic order, but legends are printed on pages preceding the plates, thus adding to the inconvenience of the reader and the cost of publication. An extensive bibliography would have been helpful to beginners or to individuals less well acquainted with the literature of North American ants. Printing costs no doubt explain this lack.

Regardless of criticisms, the publication is the most outstanding contribution of its kind that has been made to North American formicology, and it will greatly stimulate the study of ants. It will be of especial help to beginners. Dr. Creighton should be congratulated on completing this herculean task, for it required years of perseverance, patience, and fortitude. Not only should everyone interested in ants have a personal copy, but the publication should be in all important libraries dealing with biological subjects.

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INDUCTIVE REASONING

Logical Foundations of Probability. Rudolph Carnap. xvii + 607 pp. $12.50. University of Chicago Press. 1950.

THIS is the first of a two-volume work on "Probability and Induction," of which the second volume, "Systems of Inductive Logic," is still in preparation. The author is well known not alone for his articles, lectures, and reviews but also for his previous published books: *Logical Syntax of Language, Foundations of Logic and Mathematics, Introduction to Semantics, Formalization of Logic,* and *Meaning and Necessity: A Study in Semantics and Modal Logic.* Many of the views expressed in the present work are also to be found in these previous writings, but all symbols and technical terms here used (and they are many) are explained in this work. The book proposes "a new approach to the old problem of induction and probability." Although mathematical theorems are given and some numerical results are computed, most of the theorems lie rather in the framework of the lower functional calculus of formal logic. There is much food for thought for readers chiefly interested in general philosophical problems rather than in technical developments in the calculus of probabilities. No one familiar with the author's interest in clearing up semantic confusion would expect from him a work designed as a handbook in technical applied probability.

The author starts with the preliminary problem of the nature of explication, since one of his main tasks is to supply adequate explicata for two contrasting meanings of "probability" and for the current methods of inductive reasoning. Topics in deductive logic and some semantical principles are then treated, resulting in particular in a comprehensive collection of theorems in the semantical method of dealing with deductive logic in general. The perhaps unfortunate notations "probability$_1$," and "probability$_2$," for the evidential and frequency concepts, respectively, are introduced and retained throughout the work. The general concept of a confirmation-function, its relevance and specializations thereof, breaks new ground. Similarly the role of the

general estimate-function is critically examined in the light of the methods of modern statistics. Among the concepts accepted and defended as basic, are (i) all principles and theorems of inductive logic are analytic; and (ii) hence, the validity of inductive reasoning is not dependent upon any synthetic presuppositions like the much-debated principle of the uniformity of the world.

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A PHYSICIST'S LIFE

The Autobiography of Robert A. Millikan. xiv + 311 pp. Illus. $4.50. Prentice-Hall, New York. 1950.

THE career of Robert A. Millikan covers practically the whole of the new era in physics that began with Roentgen's discovery of "a new kind of light" in 1895. The book under review begins much earlier than that, going back to the time when, as a five-year-old boy, Millikan made his "first laboratory experiment." He and his father were starting out on a fishing trip. While their row boat was tied to a rough floating dock and his father was arranging his fishing tackle on shore, young Robert decided to entertain himself by jumping back and forth between the prow of the boat and the mooring platform. But the boat pushed back as he jumped forward, and he fell into the water. This, he says, introduced him to Newton's third law of motion.

The book tells the story of his college days at Oberlin and his graduate work at Columbia and in Germany. It was while he was in Germany that Roentgen's discovery was announced. In 1896 Millikan returned to America and became an assistant to Michelson at the newly opened University of Chicago. Here he remained until 1921, when he went to the California Institute of Technology. In 1923 he was awarded the Nobel Prize in physics for his researches on the elementary charge of electricity and the photoelectric effect.

During his student days in Germany he was profoundly impressed by the difference in the state of development of physics in Germany and the United States. For two years he had been the sole graduate student in physics in Columbia University. This experience influenced him profoundly in his subsequent development of courses in physics and in his writing of textbooks.

During World War I Millikan took an active part in mobilizing science for war. He was one of the founders of the National Research Council, and for a time he served in the Army, developing submarine detection devices. This experience gave rise to two chapters in his autobiography entitled The Road to Peace and Forks on the Road. The last chapter in the book, entitled The Two Supreme Elements in Human Progress, sets forth Dr. Millikan's philosophy on the relations of science and religion.

The book as a whole is interestingly written and is not devoid of flashes of humor.

PAUL R. HEYL

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A CLASSIC FOR MOVIE MAKERS

16 mm Sound Motion Pictures. W. H. Offenhauser, Jr. 580 pp. Interscience, New York. 1950.

ANYONE interested in 16-mm motion pictures either from a vocational or avocational standpoint simply cannot afford to miss this manual of 580 pages, crammed with information and with a very comprehensive index.

The author is completely sold on his subject and ably points out the great advantages of 16-mm sound over 35-mm film. First and foremost are economy and lightness, coupled with adaptability. During World War I only 35-mm film was used, whereas during the last war millions of feet of 16-mm film were shot every day, providing the foundation for hundreds of training films. Since the war educational institutions, business houses, and documentary film producers are almost 100 per cent 16-mm users.

Every conceivable problem is covered, from film characteristics, camera's sound recording, editing, assembly, and processing, down to the newest use in television. This latest field and its potentialities have hardly been touched. The future for 16-mm sound appears very favorable indeed.

Mr. Offenhauser's book will be to the movie men what Mr. Noblette's book *Principles and Practice* is to the still men.

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PSYCHOTHERAPEUTIC TECHNIQUES

The Meaning and Practice of Psychotherapy. V. E. Fisher. xv + 411 pp. $5.00. Macmillan, New York. 1950.

TWENTY years of experience in dealing with the problems of help-seeking human beings have led Dr. Fisher to the adoption of certain procedures and techniques that seem to him most effective in diagnosis, psychotherapy, and counselling. It is these that he describes in detail in this book, asserting at the outset that he does not claim any of them to be new or original.

Unlike many earlier articles and books on the subject, Fisher's volume represents an attempt to present a rationale for the *methods* described without making this a theoretical evaluation of *systems* of psychotherapy. Feeling no compulsion to cloak his thinking in the security-providing label of a "school" of psychological interpretation, the author presents psychotherapeutic techniques as a part of science rather than as a cult. Although psychotherapy as a technique leans heavily on the verbal, he shows it to be something more than merely vocal.

The book is divided into four major discussion areas. Part I considers the psychological mechanisms of approach to a new patient, including a discussion of diagnosis, types of psychotherapeutic approach, factors related to success and failure in treatment (specific aims of treatment, handling the transference relation, the

problem of plateaus in therapy, et cetera.) The author's facility for succinctly delineating these common factors takes his discussion out of the commonplace.

Parts II and III deal, respectively, with the treatment of psychotic and neurotic reactions. Case material for each of the conventional psychotic and neurotic categories is provided to illustrate the utilization of specific therapeutic techniques.

Part IV takes up the subject of maladjustive tendencies such as suicidal tendencies, compulsive drinking, symptomatic feelings of inferiority, homosexual tendences, psychical impotence, sexual frigidity, and marital discord.

Although written primarily for the professional worker in the field of human adjustment, the book should also prove interesting to the general medical practitioner and to the intelligent layman interested in maladjusted personalities.

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GUARDING OUR WEALTH

Conservation of Natural Resources. Guy-Harold Smith, Ed. xii + 552 pp. Illus. $6.00. Wiley, New York; Chapman and Hall, London. 1950.

FROM this new text one gets the idea that in the United States we are beginning to come of age in the matter of conservation of our natural resources. A quarter of a century ago it would have been impossible to publish such a book. Few people could even name our natural resources. And it is doubtful if anyone would have attempted the complicated business of presenting the facts regarding all of them from the viewpoint of a coordinated conservation program.

The whole picture is decidedly different today. This volume is the combined work of twenty men who have specialized in the study of different resources and how to conserve them. The twenty authors represent thirteen of our great colleges or universities and one Federal agency, the Soil Conservation Service, all of which now hold conservation a major objective. Furthermore, each author handles his phase of the subject with assurance and with confidence in his facts, his deductions, and his readers. The work they have all achieved is evidence par excellence of the study, planning, and actual conservation accomplishments of the past two decades.

Guy-Harold Smith, professor and chairman, Department of Geography, Ohio State University, states in the preface that the new volume was planned as a revision of *Our Natural Resources and Their Conservation,* by Parkins and Whitaker, published in 1936. The general organization is similar, but the chapters have been rewritten and nine authors added, so that the text now is a vastly greater source of data and other information about the several resources. In addition to compiling and editing the book, Dr. Smith wrote the chapters on water power, flood control, the agricultural situation, and the final chapter giving an up-to-date résumé of national planning for conservation by regions, watersheds, metal and energy centers, and by industrial and educational groups equipped to carry out much-needed conservation research. He dedicates the volume to five great advocates of conservation education who have died since 1939, among them Dr. Parkins, and Dr. Huntington, of Yale, who passed away just after completing the chapter on Conservation of Man.

As a textbook for colleges, and as a reference for students of our nation's natural resources, the new volume should be of great value. Its chapters are packed with up-to-date data and other information about soils and soil conservation, irrigation, wet lands and drainage enterprises, forests, water supplies and water uses, grassland resources, minerals and mineral fuels, wildlife and fisheries, recreational resources and human beings as the most valuable resource of all, and present-day conservation endeavors from the community to the Federal level. Errors are few, and they can be easily marked for reprinting. The chapter reference lists alone are important; they total 269 items. And the list at the end of the book, "General Works on Conservation," containing twenty-seven items, is unique in that it contains only books and reports which treat conservation of all natural resources as a major objective of modern times.

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DEVELOPMENT AND MORPHOLOGY OF DIPTERA

Biology of Drosophila. M. Demerec, Ed. x + 632 pp. Illus. $10.00. Wiley, New York. 1950.

BEFORE discussing this book it is necessary to define its scope. The word "biology" is here restricted to include only ontogeny and morphology, ignoring all the many other branches of the study of the living organisms comprising the genus *Drosophila.* One can learn here nothing about their phylogeny and only such physiology and bionomics as are essential to the capture and culture of the species. The word "*Drosophila*" in the title is scarcely used in the taxonomic sense to mean the many species of the genus as they occur in nature, but as a common name for the species *Drosophila melanogaster* as it is seen in the rearing tube or under the microscope of the cytologist or morphologist.

With these restrictions in mind, the book is a valuable source of information. Under the editorship of M. Demerec, of the Carnegie Institution of Washington, seven authorities have contributed chapters to the volume. Kenneth W. Cooper deals with normal spermatogenesis, noting the difficulties involved in the study of gametogenesis and the consequent gaps in our knowledge. B. P. Sonnenblick and D. F. Poulson deal very thoroughly with the early and late embryology, respectively, of *D. melanogaster,* and Dietrich Bodenstein carries the ontogeny on from the hatching of the egg to the emergence of the adult, a period of about 192 hours at 25° C. G. F. Ferris, in discussing the external

morphology of the adult, presents a number of conclusions not yet widely accepted or fully supported by published evidence on the grounds that a standard reference work is a poor place to perpetuate what the author considers to be erroneous conclusions. Albert Miller treats very fully the internal anatomy and histology of the imago, and, finally, Warren P. Spencer deals with the collection and laboratory culture of various species of *Drosophila,* including a certain amount of bionomic information.

The book is copiously illustrated, and each chapter has an extensive bibliography. An index to authors and a very complete subject index are also included. The aim of providing a complete description of normal *D. melanogaster,* so that any deviation from this norm may be detected, appears to have been very satisfactorily accomplished. It will, without doubt, be a standard reference work for years to come, of particular value to the geneticist and physiologist working with *D. melanogaster,* but also useful to anyone interested in the development and morphology of Diptera in general.

ALAN STONE

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U. S. PREHISTORY

Ventana Cave. Emil W. Haury. xxvii + 599 pp. Illus. $15.00. University Arizona Press, Tucson, and University of New Mexico Press, Albuquerque. 1950.

EMIL W. HAURY and his associates have given us, in *Ventana Cave,* a welcome new publication in the field of archaeology. The cave is a shelterlike opening under volcanic rock in Ventana Mountain, a spur near the south end of the Castle Mountains in the Papago Indian Reservation, southwestern Arizona. The rock shelter opening extends along the face of the mountain in a southwest-northeast direction, the habitable part having an over-all length of about 175 feet. The opening thus faces southeast, always a favorite setting for human cave habitation, affording, as it does, protection from winter winds. The shelter is divided by a natural rock partition into two parts connected by one small opening. That part of the shelter to the southwest of the partition, being somewhat higher in elevation, is referred to by the authors as the upper cave, the part to the northeast of the partition, the lower cave. The opening of the lower cave extends along the mountainside about 55 feet, its depth back under the ledge of volcanic rock being about 20 feet. The upper cave is larger and has an opening extending perhaps 115 feet along the mountainside. Its extent back into the mountain varies from about 25 feet near the partition on the northeast to as much as 65 feet at the southwest. In the widest part of the upper cave is a permanent spring, an unfailing attraction for human habitation.

The geologic formations in the cave (omitting details) are as follows: Conglomerate deposited on the original rock floor of the cave; resting on the conglomerate, a stratum chiefly of volcanic debris, with some fallen rock from the roof of the cave; above the volcanic debris and of limited distribution, a hard, pinkish, sand stratum; elsewhere in the cave at about the same level as the sand, talus material washed into the cave. The four horizons, having a combined thickness of five or six feet, represent the water-deposited formations of the shelter and occur only in the upper cave. Of later age, extending over both the upper and lower caves, and having a maximum thickness of ten feet, are deposits consisting chiefly of fine dust, animal bones, fragments of rocks, and debris resulting from human habitation. These later, chiefly midden, deposits form the present floor of the cave.

The great importance of this cave to archaeology is the record here preserved of the succession and relative age of several human cultures. The basal deposit, a conglomerate, contains charcoal and one or two artifacts, affording some evidence of human habitation at that time. The oldest identifiable culture, found in the next-to-the-lowest horizon in the cave, clearly represents an ancient human dwelling place. The man-made objects found at this level, all of which are of stone, include projectile points, knives, scrapers, gravers, choppers, planes, hammerstones, and grinding stones. Of projectile points, unfortunately, only two were found, and these, oddly enough, were entirely different from one another. One is of the size and shape of the projectile point of the Folsom culture except that it lacks the most distinctive Folsom characteristic, namely fluting. The other point is slightly notched at the base and is evidently of a culture quite apart from Folsom. Of a total of 88 other artifacts obtained at this level, 63 were scrapers of various kinds. The considerable antiquity of these artifacts is proved by their association with the fossil remains of at least five species of extinct animals: four-pronged antelope, native American horse, great jaguar (*Felis atrox*), sloth, and tapir.

Next above the volcanic debris stratum is a red sand, which, although of limited extent, nevertheless yielded a distinctive type of projectile point which the author has named the Ventana-Amargosa point. The associated animals at and above this level are of modern species, indicating that considerable time intervened between the deposition of the volcanic debris and of the red sand, during which both the vertebrate fauna and the human culture changed.

Above the red sand horizon the deposits are largely made up of debris accumulated incident to human habitation. How profuse were the artifacts of this midden material is indicated by the fact that from these deposits in excess of 11,000 stone artifacts were obtained. These are not only too numerous but likewise too diverse for description here. Pottery is present only in the uppermost three feet of the midden deposit. The upper few feet of the midden material are dry and free of moisture. Within this part of the cave were many burials in which not only skeletons and ornaments, but fiber, horn, and textiles were preserved, furnishing an important record of the inhabitants of the cave in relatively recent time.

The publication is a monumental contribution to a most important subject, the prehistory of the southwestern United States.

E. H. SELLARDS

Texas Memorial Museum
Austin

Sir William Osler: Aphorisms from his Bedside Teachings and Writings. William Bennett Bean, Ed. 148 pp. $2.50. Schuman, New York. 1950.

FOR this small volume Dr. William Bennett Bean has taken from the collected notes of his father a large number of the daily comments of Sir William Osler. The elder Dr. Bean made many of these notes during bedside rounds and lectures and supplemented them from the writing of Dr. Osler.

Sir William Osler exerted as much influence on modern medicine as any doctor of his time, and his observations and cryptic advice on various aspects of medical science, student problems, patient care, and his general philosophy are at once witty, humorous, shrewd, and practical.

The book is short but will reward anyone who reads it, and will bear rereading from time to time for the wealth of comment in it.

ALLEN E. HENKIN

Washington, D. C.

Goethe the Scientist. Rudolf Steiner. 280 pp. $3.50. Anthroposophic Press. New York. 1950.

FAMOUS for his drama *Faust* and for his poems, Goethe has not been so well known as a scientist. As Steiner, himself a philosopher, points out in this learned treatise, although there were much philosophy and empirical idealism in his theories, Goethe made notable contributions to knowledge in the fields of morphology, botany, zoology, and meteorology. His "idea of a living entity is not applied at once to an individual organism, but that the entire universe is conceived as such a living being." His theory of an archetypal organism with a capacity to take manifold forms best suited to external environment showed him to be tending toward (later) Darwinism.

An important discovery of the intermaxillary bone in man removed the only formerly supposed difference between man and the apes. Goethe's vertebral theory of the skull, or the discovery that the skull bones were modified vertebra, had far-reaching significance. His fundamental ideas were now crystallized, and he began his treatise on the formation of animals.

Goethe was searching for ideas; facts or discoveries were important only as they confirmed his belief in the consistency of nature. There is (he thought) harmony in all nature. In him "one sees the harmony of art and knowledge realized in one personality."

MARJORIE B. SNYDER

Washington, D. C.

An Annotated Check List of the Reptiles and Amphibians of Texas. Bryce C. Brown. xii + 259 pp. $4.50. Baylor University Studies. Baylor University Press, Waco, Tex. 1950.

THIS book is much more than an "annotated check list." The writer dedicated it to John K. Strecker, "Father of Texas Herpetology," who published the last Texas herpetological check list in 1915, at which time 181 forms were recognized. The present list includes 225 forms, shown tabularly as occurring in eight "natural regions of Texas." A simple outline map, showing the eight regions, would have been of value to non-Texan readers. The synonymy is treated in the most approved form, the genera and species are listed alphabetically, numerous keys help in identification of specimens, and every authentic locality record is given.

The book is a "must" for students of Southwestern herpetology.

CHAPMAN GRANT

San Diego, California

The Ecology of Animals. (3rd ed.) Charles Elton. 97 pp. $1.25. Methuen's Monographs on Biological Subjects. Wiley, New York. 1950.

ANYONE who wishes a broad, comprehensive, and thoroughly intelligible survey of the intricate subject of the interrelationships of animals with each other and with their environment cannot do better than to study this book. The broad outline of the subject is supplemented by a well-selected list of 167 references. The book is singularly free from typographical or other errors. However, on page 79, by an oversight, Elton refers to the tsetse fly (*Glossina*) as a tabanid (Tabanidae), whereas it is a muscoid fly (Muscidae) related to the stable- and houseflies.

AUSTIN H. CLARK

U. S. National Museum
Washington, D. C.

LETTERS

PLANNING IS ESSENTIAL: WE MUST MAKE IT GOOD

It is a frequent source of amazement to me to see how little of the scientific method is to be found in scientific publications when the subject under consideration lies outside the physical sciences. Ruth Shallcross' article, "A Planned Economy: Good or Bad," is a striking example.

Thus, Dr. Shallcross quotes one sentence from the late Joseph Schumpeter's classic book *Capitalism, Socialism and Democracy* to make a certain point, without acknowledging that the whole book is a long argument that "the march into socialism" will go on. Schumpeter is indeed critical of orthodox Marxism, but that is not the question under discussion. In her quotation from Dr. Schumpeter, without further explanation, Dr. Shallcross is guilty of a quite unscientific use of argument from authority.

Later on, in her quotation from John Jewkes' book *Ordeal by Planning,* she is guilty of using an ex parte statement about a particular and dated crisis in the emergency of postwar recovery in England as if it were fairly descriptive of the whole process. As a matter of fact, the economic progress of England has been greater than in any other European country in respect to production and equitable distribution of goods. The British achievement is a phenomenon not without faults, but unparalleled in the history of human action in like emergencies. Production is about 30 per cent above 1938, the last prewar year.

A further illustration of Dr. Shallcross' unscientific method is to be found in her interesting paragraph on the extraordinary value of prices, "as important a measure in determining the higher economic goal as instrumentation is in determining scientific goals." She does indeed admit that prices are not "precise in a physicist's concept," even in a free market. But she does not discuss at all the fact that for generations we have not had a truly free market but one profoundly affected by tariffs and private monopolist control. Monopoly and oligopoly arose at least in part as an answer to the chaotic competition in prices, for instance, in fixing railroad fares, under a purely competitive system. At the turn of the century both Rockefeller and Morgan, each in his own way, could have argued that they were rendering a public service in policing the market against cutthroat competition in which wages and consumers' interests were the victims. I do not know any considerable number of economists in the United States who will not agree that prices are, to a very substantial degree, determined by collusive controls. Only partially are they determined by competition, a competition which no modern socialist planner wants wholly to eliminate. Witness the course of events in the Scandinavian countries and Great Britain.

Oscar Lange is author of the classic argument that under socialism or a planned economy a large number of prices can be fixed by natural processes rather than decreed by planners. Dr. Shallcross' attempt to dispose of this whole argument in one brief paragraph, by saying that it would be impossible without actually having a free market, is about as unscientific as if I were to argue that prices have no value now as expression of consumers' desire because in our present economy we do not have a truly free market.

But her greatest mistake from a scientific point of view is her refusal to face the facts of our economic history except when one or another of them out of context seems to fit into her theory.

The famous depression that began in America at the end of 1929 did not overtake an economy wholly determined by a free market. It was, on the contrary, an economy that had been profoundly affected by a world war and its aftermath, an economy in which the 200 largest business corporations controlled more than 50 per cent of the business wealth. It was, however, what many businessmen and employers would regard as an unplanned economy. It was almost totally destitute of welfare features. Wall Street had little to fear from Washington.

The depression which overtook this unplanned economy brought a degree of ruin to individual welfare that it would be difficult for any planned economy, however bad, to duplicate. Under Roosevelt, planning, including welfare measures borrowed from socialism but falling far short of socialism, proved of indescribable benefit to the American people. By a certain degree of planning, Roosevelt rescued the entire banking system. But Roosevelt was unable, or unwilling, to apply social controls and that constructive planning that might have ended unemployment. So, on the eve of Pearl Harbor, we had some 10 million unemployed, and it was only after Dr. Win-the-New Deal, in Roosevelt's own phrase, became Dr. Win-the-War that unemployment gave way to manpower shortage. War economy is perforce a planned economy, and a very arbitrarily planned economy, without direct reference to the economic well-being of the people.

It is a paradoxical fact that, although the indefinite continuance of an arms economy threatens us with economic disaster, it has thus far been a bulwark against unemployment and depression and a contributory factor to our inflationary prosperity. Most economists will agree that the economic recession of 1949 was prevented from becoming depression by various factors, of which by far the most important was the magnitude of Federal expenditures on arms. And that was before the Korean

war. Especially in view of that war and a possible annual military budget of 42 billion dollars, it makes no sense to write on planned economy and utterly ignore the fact that the arms race has forced upon us a high degree of governmental control over our whole economy. The only question that has validity is the extent and nature of the governmental controls that we must accept.

Let me go farther. If angels from heaven should proclaim in all our churches next Sunday everlasting peace and the everlasting end of that monstrous race in arms which gives the world bombs rather than bread, there would be a world-wide panic on Monday—that is, unless governments were ready with plans for a general war against want at home and abroad. Again, the question would not be "planning: good or bad" but what kind of planning, how much, and under what controls.

Indeed, we have come to a time when even if there were no cold war, the widespread hunger of swarming multitudes can only be dealt with by planning. Two thirds of the world's inhabitants are undernourished by American standards; half of them live face to face with starvation. The expectancy of life in India is less than half that of America, and the principal reason is lack of food. Experts tell us that we have enough collective knowledge to double the world's food supplies, and theoretically we have the physical facilities to distribute what we could produce. But this can only be done by extensive and competent planning on an international scale, with the help of organizations like the United Nations FAO.

Even in our fortunate United States, it has long been evident that we could not leave the supply of food solely to the working of that market economy in which Dr. Shallcross puts her trust. To keep farmers on the job and to get production, it has been necessary to give them economic guarantees which "free enterprise" does not provide. The way in which we have done this is open to criticism. It is highly significant that in the Presidential campaign of 1948 I, a socialist, was the only candidate to challenge the outrageous subsidy paid that year to potato growers through parity devices. In this case there was not even a way to distribute potatoes to the hungry.

A valuable study of conditions in China before the Communists took over the government was made by an American expert, Gerald Winfield. He reports on it in his book *China: The Land and the People*. He closes with a constructive program for increasing China's food supply. It requires a coordination of reforestation, flood control, the development of hydroelectric power for making fertilizer, conservation and restoration of the soil, the eradication of parasites, and proper agricultural techniques. It would be completely impossible to dream of carrying out such a program in any hungry country so long as men persist in wasting their energies on an abstract and theoretical discussion of "planning: good or bad."

It will be observed that the Shallcross article was not a discussion of socialism but of planned economy, which is not necessarily identical with socialism. Nothing is clearer than that we have already accepted a mixed or scrambled economy in which there has to be a very considerable degree of planning. That planning is made more difficult and less satisfactory because most Americans pretend not to believe in it and have not made up their minds whether the dominant loyalty ought to be cooperation or a grab for private profit. We are further confused because we do not think of planning except in terms of static blueprints for a building, whereas in reality we are dealing with living beings and inevitable change. Nevertheless, whatever our excuse for our blindness to facts, already American politics and economics are bound up with planning, not only by governments from the local to the Federal level, but by the United Nations and its organs. We live in a welter of Marshall plans, rearmament plans, disarmament plans, and the economic controls necessary for them: plans for social welfare, including housing and systematic provision for education and public health.

In such a country and such a world, it is our business to make up our minds to accept the dominant loyalty of cooperation and, inspired by it, to plan for plenty, peace, and freedom. They cannot possibly be the products of laissez-faire economy or of self-sufficient nationalism. The blind effort to oppose all government planning, including planning by the United Nations, plays into the hands of the totalitarians. Dr. Shallcross, by arguing for the nonexistent and impossible in the world, makes it harder for those whose planning includes belief in variety of instrumentalities and large place for individual enterprise. In answering her, I am under no logical obligation to defend socialist planning. But, obviously, he who supports planning will win more attention if even briefly he states his own position. Here is mine.

We democratic socialists believe that the great American community, loyal to the principle of cooperation for achieving plenty and peace and freedom, will make extensive use of government as our servant. Government planning will operate through tax and fiscal measures and a broad program of social welfare. It will be most democratic and most efficient if it insists on social ownership of the commanding heights of the economic order. They are: our forests and minerals; our system of money, banking, and credit; our great monopolies and oligopolies, in which ownership has already lost its managerial functions. The managers, key men in modern industry, should be working for society and not for absentee owners. Private ownership of land for homes and farms should rest on occupancy and use. Rental value of land belongs to society, which creates it, and the state should take it by a tax.

Social ownership can be exercised through cooperatives as well as through the state. State-owned enterprises should not be run like the Post Office Department, but under public authorities which should be controlled by boards organized to represent consumers and the workers in the socialized industries. The latter should elect their representatives. In normal times and

under a peace economy there would not need to be much if any specific price fixing. The community through government should hold in reserve the power to determine priorities in access to scarce materials, to prevent waste, and to guide investment, especially when depression threatens.

We should still have a lot of planning in our economy even if there were less social ownership than I suggest. Actually there is greater danger of bureaucracy in an objectionable sense in endless regulation of privately owned utilities than in the operation of publicly owned utilities as under TVA. A condition of safety in planning is careful protection of rights of criticism or, more accurately, vigilant assertion of all our civil liberties.

What I have been saying is an outline for a book. In this letter it can only suggest the lines along which planning, which has become essential in our society, may also be good.

NORMAN THOMAS

39 A Gramercy Park
New York City

ERRATUM

Unfortunately, the map on page 292 of my article on "Antarctic Mapping and Aerial Photography," which appeared in the November issue of THE SCIENTIFIC MONTHLY, did not give credit to the American Geographical Society as the producer. "Prepared by the American Geographical Society" should have appeared in the caption.

The American Geographical Society, from my very first contact with it in 1944, has been extremely cooperative and helpful to me and the expedition, and greatly assisted me in getting the expedition off. I am sorry that through my neglect injustice has been done to the cartographic staff of the American Geographical Society in not giving them due credit for their work. . . .

FINN RONNE

Silver Spring, Maryland

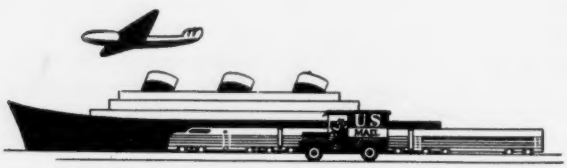
PHYSICIST'S WIFE

Words he likes are words for duty—
Those for service, not for beauty.
Franklin, Dalton, Roentgen, Ohm
Are the idols of our home.

To him, Edison and Bell—
Volta, Oersted, Field as well—
Watts and Pascal, Newton, Wright
Are a source of deep delight.

Armatures and dynamo,
Ergs and such are good to know—
Series, parallels, and coils
Worth his endless time and toils.

Swiftly, surely he will speak
Of neutrodyne and hygrodeik—
And Shakespeare's name to him is truly
Lesser far than great Bernouilli.

I'm the moron—and in truth
A feature he acquired in youth—
But, though my ignorance must tire him,
This he knows: *gosh, I admire him!*

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